Regional Meeting–
Committee Week

Columbus, Ohio, March 6-10

Symposia on Thermal Insulating Materials and Lime–
(Abstracts on page 29)

•

Active Work Under Way–
1938 Reviewed

•

Standard Tests on Building Brick

•

Non-Destructive Testing–
Radiographic Methods

•

January, 1939

BVLLETIN

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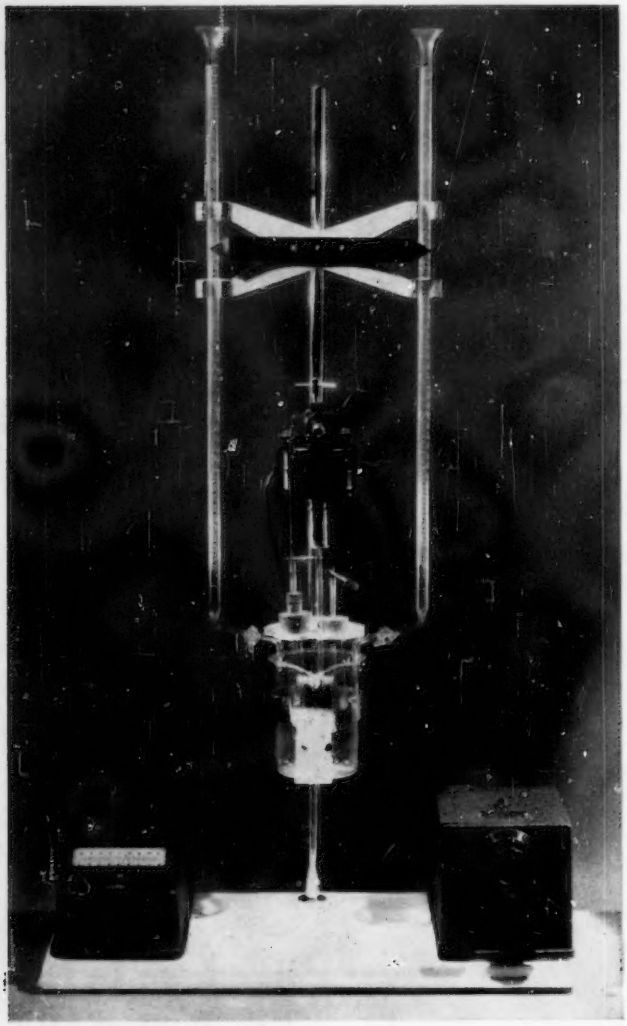

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260 SOUTH BROAD STREET PHILADELPHIA, PA.

"Promotion of Knowledge of Materials of Engineering and Standardization of Specifications and Methods of Testing"

TELEPHONE—PENnypacker 3545 CABLE ADDRESS—TESTING

Number 96 January, 1939

Regional Meeting and Committee Week, Columbus, Ohio, March 6 to 10

Symposiums on Thermal Insulating Materials and Lime

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FROM Monday, March 6, through Friday, March 10, there will be in progress in Columbus, Ohio, at the Deshler-Wallick Hotel, the 1939 Spring Group Meetings of A.S.T.M. committees. The high point of Committee Week will be the Regional Meeting on Wednesday, March 8. In the afternoon, the Symposium on Thermal Insulating Materials will be presented. On Wednesday morning it is planned to hold a Symposium on Lime.

In charge of local arrangements for the meeting is a committee located in the Columbus area with C. E. MacQuigg, chairman, and W. W. Heimberger, secretary. The officers of the committee are as follows:

COLUMBUS COMMITTEE ON ARRANGEMENTS

C. E. MacQuigg, *Chairman*, Dean, College of Engineering and Director, Engineering Experiment Station, Ohio State University.
W. W. Heimberger, *Secretary*, The Buckeye Steel Castings Co.
James R. Withrow, Department of Chemical Engineering, Ohio State University, *Chairman*, Committee on Symposium on Lime.
O. E. Harder, Assistant Director, Battelle Memorial Institute, Committee on Symposium on Thermal Insulating Materials.
Ross C. Purdy, General Secretary, American Ceramic Society, *Chairman*, Entertainment Committee.
E. W. Campion, President, The Bonney-Floyd Co., *Chairman*, Plant Inspection Committee.
H. A. Depew, American Zinc Oxide Co., *Chairman*, Registration Committee.
Paul C. Hodges, Marble Cliff Quarries Co., *Chairman*, Publicity Committee.

THERMAL INSULATING MATERIALS

The committee in charge of the Symposium on Thermal Insulating Materials headed by J. H. Walker, The Detroit Edison Co., Chairman of Committee C-16 on Thermal Insulating Materials which with Committee C-8 on Refractories is sponsoring the symposium, has had splendid cooperation from the authorities who are preparing the four technical papers comprising the symposium. The papers are as follows:

FACTORS INFLUENCING THE THERMAL CONDUCTIVITY OF NON-METALLIC MATERIALS
METHODS OF TESTING THE PHYSICAL PROPERTIES OF PRE-FORMED AND PLASTIC THERMAL INSULATION
ONE CONSUMER'S PROBLEMS IN SELECTING HEAT INSULATION
THE EFFECT OF SOLAR RADIATION ON THE HEAT TRANSMISSION THROUGH WALLS

Extended abstracts of the papers have been prepared by the authors and in order to stimulate discussion and comment these abstracts are published in this BULLETIN (see page 29). They give an idea of the information and data that will be presented in the symposium and should afford sufficient information on which to base discussion. Written discussion should be submitted to the Secretary-Treasurer at Society Headquarters well in advance of the meeting and preferably in triplicate.

The papers in the Symposium on Thermal Insulating Materials will not be duplicated in advance of the meeting in view of the publication of the extensive abstracts in this BULLETIN. Attention is directed to the note on the abstract of the paper on "Factors Influencing the Thermal Conductivity of Non-Metallic Materials," indicating that there are available two or three copies of the manuscript of this extremely extensive contribution and those who definitely have in mind presenting written discussion can borrow a copy for a few days, if desired.

80-ton Cyclotron Under Construction at Ohio State University
This atom smasher is being constructed by the Department of Physics in cooperation with the Department of Electrical Engineering. It will be one of the largest that has been built. When finished it will aid in a number of research projects.

Presiding officers during the symposium session will be J. H. Walker as Chairman and O. E. Harder, Assistant Director, Battelle Memorial Institute, who represents the Local Committee on the Thermal Insulation Symposium Committee.

SYMPOSIUM ON LIME

While Committee C-7 on Lime has been acting as a committee of the whole in charge of the Symposium on Lime, four of the members, Prof. James R. Withrow, *Chairman*, John W. Stockett, Jr., *Secretary*, L. E. Johnson, and F. O. Anderegg have been directly responsible for its development. J. C. Pearson represents Committee E-6 on Papers and Publications on the Lime Symposium Committee. A number of technical papers will be included, among them the following:

FACTORS AFFECTING MILKS OF LIME EMPLOYED IN INDUSTRY—D. E. Washburn.
HYDRATION OF MAGNESIAN LIME AND THE AUTOCLAVE TEST—F. C. Welch.
LIME CHARACTERISTICS AND THEIR EFFECT ON CONSTRUCTION—Walter C. Voss.
MANUFACTURING LIME FOR THE GLASS INDUSTRY—A. H. Nieman.
VARIATIONS IN PROPERTIES OF DOLOMITIC LIME PUTTIES WITH METHODS OF HYDRATION—John E. Conley.
PRELIMINARY INVESTIGATION OF THE DETERMINATION OF FLUORINE IN LIME—C. J. Koehler.
THE BASIS OF STANDARDS FOR LIME FOR THE SOIL, UP TO DATE—E. O. Fippin.

Attention of members of the Society is directed to the note on this page asking that those who are interested in obtaining copies for purposes of discussion should advise Society Headquarters.

Presiding officers during this session will be Prof. James R. Withrow as Chairman and F. O. Anderegg.

ENTERTAINMENT; "SCIENCE AND ENGINEERING IN BIOLOGY AND MEDICINE"

The Committee on Arrangements is making plans for the entertainment of members during Committee Week in Columbus. It is expected that certain industrial plant trips and other trips will be available for those who wish to take advantage of them. Further details of visits which can be arranged will be available at the A.S.T.M. registration desk.

The major item in the entertainment program is in the nature of an "Open House" at Ohio State University, Wednesday evening, March 8. An unusual treat is in store for the members no matter what their industrial interests may be. No dinner or speakers' program is planned because of this Open House and its accompanying demonstration and exhibits.

The Ohio State Chapter of the Society of the Sigma Xi, in cooperation with the College of Medicine, will plan a demonstration on Science and Engineering in Biology and Medicine. Similar demonstrations have featured other meetings at Ohio State and in each case have been received with intensive interest on the part of those attending. Quite a number of items are included in the program, some of which are expected to be as follows: demonstration of the iron lung; studies in nutrition; illustration of heart action by a sectioned beef heart provided with windows and pump plunger; illustration of stimuli and depressants on the heart action of a "pithed" tortoise; broadcasting of human heart beats by radio pickup; demonstration of bio-electrical currents, etc. There will be other items of general scientific interest and because of the outstanding caliber of the scientists who are in charge of developing the program, there is no doubt it will be one that members should not miss.

1939 COMMITTEE WEEK

From Monday through Friday, March 6 to 10, meetings of a large number of A.S.T.M. committees, their subcommittees and sections will be in progress. Since 1939 is a "Book of Standards" year there is intensive activity on the part of many groups to bring their specifications up to date. Committees which have thus far signified their intention of participating in the meetings are as follows:

A-7 on Malleable Iron Castings
A-10 on Iron-Chromium-Nickel Alloys
B-3 on Corrosion of Non-Ferrous Metals
B-5 on Copper and Copper Alloys
B-6 on Die-Cast Metals and Alloys
B-7 on Light Metals and Alloys
C-1 on Cement
C-7 on Lime
C-8 on Refractories
C-9 on Concrete and Concrete Aggregates
C-12 on Mortars for Unit Masonry
C-16 on Thermal Insulating Materials
D-4 on Road and Paving Materials
D-8 on Bituminous Waterproofing Materials
D-11 on Rubber Products
D-18 on Soils for Engineering Purposes
Technical Committees and Sections of Committee E-1 on Methods of Testing
E-2 on Spectographic Analysis
Research Committee on Fatigue of Metals

This is only a partial list and it is quite probable that other groups will take part. While the final schedule of meetings and room assignments will be available at the A.S.T.M. registration desk at the Deshler-Wallick Hotel, an advance schedule will be mailed to the members of all committees meeting, early in February. This material will also carry further announcement of the Regional Meeting and other information.

It is planned to duplicate the papers or abstracts in the Symposium on Lime in advance of the meeting. Members who wish to have copies in advance for the purpose of submitting discussion should write Society Headquarters. In the case of both symposia, written discussion of the papers should be received as far in advance of the meeting as possible, preferably in triplicate.

Much Active Work Under Way; Noteworthy Progress in 1938 in Both Standardization and Research

Statements of Committee Officers Outline Many Active Projects Under Way and Indicate Important Accomplishments During the Past Year

EACH year, the January issue of the ASTM BULLETIN has carried a condensed review of some of the important achievements of the Society and its committees during the previous year *and* in addition much of the article has been devoted to a preview of what the committees are working on, thus indicating what some of the developments may be in the near future. For the past two or three years, the trend has been to make the article more of a preview than a review article and this trend is continued this year.

The material dealing with particular materials fields is based largely on statements furnished each December by committee officers.

The committee material is segregated in accordance with the sequence of committee designations. The "A" group (ferrous metals) appears first followed by the "B" group (non-ferrous metals and alloys) and then the "C" committees (cementitious, ceramic, concrete and masonry) and finally the "D" committees covering a wide range of materials.

In 1938 the Society reached the age of two-score years since it was organized as an American Section of the International Association in 1898, becoming formally incorporated in 1902. From the standpoint of years one might say the Society is becoming of age, but some anonymous writer has mentioned that "youth is not a time of life, but a state of mind. It is a temper of the will, a quality of the imagination." Viewed from the angle of activity, work accomplished and activities in progress, A.S.T.M. is distinctly on the youth side. Last year was one of the most active in the Society's history. On both its major fronts—standardization and research—notable advances were made and in other closely related fields much progress can be reported.

MEETINGS—ANNUAL, REGIONAL, DISTRICT

The Forty-second Annual Meeting in Atlantic City featured a strong technical program and this, together with a large number of committee meetings, brought forth a total registration exceeded only by the 1937 meeting in New York and the 1931 meeting in Chicago. From the technical angle, the outstanding feature was the Symposium on Impact Testing with its nine extensive technical papers, bringing up to date the latest thoughts on this question which is of growing concern in many fields. There were strong programs in other fields, notably in the subject of radiography. At this meeting, three active and long-time members of the Society were awarded Honorary Membership—Messrs. F. O. Clements, W. K. Hatt, and H. F. Moore—and certain companies and individuals who have been affiliated with the Society continuously over 40 years were recognized. The First Photographic Exhibition was held on the theme "Testing" and evinced much interest and showed some of the very excellent photographs by members and others of testing machines, processes, etc.

The largest attendance so far turned out at the 1938 Regional Meeting in Rochester, the first formal meeting held in this center by the Society. The Symposium on Plastics sponsored by the Society's Committee D-20 on Plastics was the technical feature, directing attention to important problems in this field, particularly the importance of standardizing test methods for determining the various properties. During Committee Week, held concurrently, there were more meetings of A.S.T.M. committees than in any other like period.

Several notable local or district meetings were sponsored by district committees in various centers. At the Philadelphia meeting, Dr. L. W. Chubb, Director of Research, Westinghouse Electric and Manufacturing Co., spoke on "Fundamental Research in Industry," and Dr. Stroud Jordan, formerly Chief, Bureau of Standardization, Department of Purchase, Central Testing Laboratory, City of New York, addressed the meeting in New York City in November on "The Quality of Materials." The technical feature of the Pittsburgh meeting held in November was a series of four papers dealing with "Examination of Materials by Microchemical Methods." Dr. F. N. Speller spoke to the Cleveland members at their meeting in December discussing current problems in the corrosion field.

The Northern California District Committee, centered in San Francisco, and the Southern California group in Los Angeles, held meetings during the visit of the Secretary-Treasurer to the Coast in September. These were fruitful in many ways.

The four technical papers comprising the Symposium on Protecting Metals Against Corrosion which was held at the Detroit meeting in April were of such interest that they were issued in a special booklet.

All of these meetings were considered very worth while. They have emphasized in the respective localities the important work the Society is doing in the materials field and afforded members an opportunity to get together socially.

EXTENSIONS OF COMMITTEE WORK

During the year, two new standing committees were organized, Committees E-7 on Radiographic Testing and C-16 on Thermal Insulating Materials. The former sponsored an excellent session on radiography at the annual meeting and Committee C-16 is developing the Symposium on Thermal

Insulating Materials concerning which detailed announcements appear in this issue, see page 1. A large number of the other standing committees have organized new sections or subgroups to tackle problems on many new subjects in their jurisdiction. Details of some of these appear in the discussion of committee activities which appears later in this article.

PUBLICATIONS

Some mention of the extensive publications that have been issued is in order. There is no doubt that the publications of the Society are being used more and more widely, and consequently the results of Society work are becoming known to a still wider audience. The usual regular publications were issued during the year, *Proceedings*, A.S.T.M. BULLETIN, Year Book, Index to Standards, etc., and a number of special technical volumes were also published. One of the most notable was the volume on Creep Data issued as the result of extensive work of the Joint A.S.T.M.—A.S.M.E. Research Committee on Effect of Temperature on the Properties of Metals. For the first time a special compilation of standards covering pipe and piping materials for high-temperature and high-pressure service was issued. Consideration is being given to the possibility of publishing during next year in one cover all of the Society specifications for steel tubing and pipe.

STANDARDIZATION

More new tentative standards were issued during 1938 than in any previous year and with the adoption of a large number of previously proposed standards the total number of standard and tentative specifications and tests is now 870. This compares with 563 in 1929 and 200 in January, 1919. Several committees were able to consolidate requirements for various grades of material previously covered in different specifications into one document.

The year 1939 is certain to be one of the most active in standards work because it is a Book of Standards year and all of the committees are reviewing existing tentative specifications to determine their suitability for adoption as standard and at the same time most of the committees, including some of the most recently established ones, will offer a large number of new specifications covering products for which there have not previously been issued standardized specification requirements.

RESEARCH

The October BULLETIN carried a condensed review of new research projects which supplemented the complete list published in the 1937 October issue. At the present time there are some 153 separate research projects being carried on, fifteen or more of these having been initiated during the past year. Of course these totals are constantly changing, since new projects are being started throughout the year as committees find it essential to develop basic information and data.

Further details of the Society's standardization and research activities and related topics are given in the statements which follow. In this material, the major advances in 1938 are recorded, but the material primarily stresses work under way or what with normal progress can be expected during the coming year.

Steel

The active work of Committee A-1 on Steel in developing specification requirements for a large number of steel products in its jurisdiction continued unabated during 1938. New specifications for normalized, quenched-and-tempered alloy-steel forgings were developed as a revision of an existing standard and new specifications for lap-welded and seamless steel and lap-welded iron boiler tubes were accepted, the existing standard being withdrawn. The latter included a medium carbon grade, but because of the extent of use of this grade and desirability of changes, separate new specifications covering this grade of seamless steel boiler tube were developed. Other new specifications cover seamless carbon-molybdenum boiler tubes and spiral welded steel or iron pipe. Several tentative standards were adopted as standard and a number of existing revisions were also approved for incorporation in the standards.

The pronounced interest in tubular products will continue during 1939. Specifications are being developed for heat-exchanger and condenser tubes and for steel boiler tubes for high-pressure service fabricated by the electric-resistance-welded process. An active program involving standardized requirements for steel springs and spring wire is under development with a new section being formed comprising technologists closely familiar with problems in this field. There is a very pronounced interest in welding requirements, and specifications are nearing completion for cast valves and fittings for welding and wrought welding fittings. For several years one of the most active groups has been that concerned with materials for high-temperature service, and there are a number of problems in this field on which it is hoped some action can be taken during the year. An indication of the amount of work confronting the committee is evidenced by the necessity of renewing the January meetings of the Steel Committee. Practically all subcommittees are participating this year.

Wrought Iron; Cast Iron

To make desirable modifications in the hydrostatic pressure requirements, Committee A-2 on Wrought Iron proposed revisions which were immediately adopted in the specifications for welded wrought-iron pipe (A 72). It is concerned currently with permissible variations for bars for staybolt material, and is organizing an effort to bring into line tolerance requirements for various purposes.

On the recommendation of Committee A-3 on Cast Iron, specifications for cast-iron culvert pipe (A 142) were adopted as revised and proposed revisions in the requirements for gray-iron castings for valves, flanges and pipe fittings were published as tentative. The proposal includes the addition of a class of high-test iron with corresponding requirements on physical properties including tensile strength of not less than 41,000 lb. per sq. in. The committee is investigating the properties of chilled and white-iron castings.

Corrosion of Iron and Steel

Committee A-5 is continuing its exposure tests as follows: black sheets, Annapolis; galvanized sheets and hardware, State College, Pittsburgh, Altoona, Key West, and Sandy Hook; total immersion tests of uncoated iron and steel products, Key West, and Portsmouth, N. H.

Exposure tests of galvanized wire products are well under way. The Inspection Committee, headed by C. D. Hocker has made four field inspections at the Pittsburgh Test Station, three at Bridgeport, State College, and Sandy Hook and two inspections at the other locations. (See 1937 A-5 Report.) So far no coating failure has occurred on any samples exposed at the college test locations.

The report of failures to date will be incorporated in the 1939 report of the committee. A scheme is being worked out for reporting the information obtained at the inspections in such a way:

(a) that the same reporting form can be used from year to year by filling in new data obtained.

(b) that a general over-all picture may readily be obtained of the large mass of data collected.

This year it is planned to remove from the test racks the first set of wire samples for tension testing and loss in weight determinations. These results will appear in the next report of Committee A-5, together with a report of all the work done at the National Bureau of Standards by the Research Fellows employed by Committee A-5, which will include full details of mechanical testing methods used in making the tension tests and bend tests on wire samples, chemical analytical methods used in determining the composition of the zinc coatings, and the base materials, and methods used in preparing micro-sections as well as photomicrographs of the coatings on the various wire products.

The committee plans to expand its tests on protective coated hardware materials. A critical study of the hardware data has indicated there are certain gaps existing in the information secured and the committee has decided to remedy this by expanding the program.

In its latest report, the committee has discussed in detail results of tests on galvanized sheets and on uncoated sheets and has included in voluminous tables the latest information resulting from the tests on hardware, structural sheets, tubular shapes, etc.

There was issued in 1938 a test for uniformity of coatings on castings and forgings (A 208). The standard specifications for zinc-coated sheets (A 93) were extensively revised in the form of new specifications and the tentative test for uniformity of coating on iron and steel wire (A 191) was adopted with some revisions. The committee will welcome comments on whether this general specification for sheets (A 93) is more useful than individual requirements directed to specific uses. Work is under way on specifications for zinc coatings on chain link fencing and on the revision of existing specifications for zinc coatings on wire strand (A 122).

Drafts of requirements for determining the weight and thickness of electroplated coatings are being considered by the committee and, when approved, it is intended that they will be incorporated in the three specifications covering electrodeposited coatings of zinc, cadmium, nickel and chromium on steel. Studies will be made of the application of the Preece test in determining uniformity of coating on bolts, nuts and similar small objects. It is planned also to investigate the preparation of standards covering the exposing of test specimens and making of immersion and salt spray tests.

Magnetic Properties

There are several projects involving magnetic properties on which work is under way through Committee A-6. These include the following:

1. Continued consideration of definitions and nomenclature with special reference to terms relating to incremental permeability.
2. Continued investigations in the field of testing with high magnetizing forces.
3. Specifications for the determination of space factor.
4. Investigation of the use of small Epstein apparatus for the determination of core loss with the end in view of preparing specifications.
5. Investigations in the field of testing with superposed a-c and d-c magnetizing forces, first attention to be given to low values of induction.
6. Study of possible ways of stimulating developments in the field of magnetic analysis.

An important new test method was issued as tentative in 1938 for measuring inter-lamination resistance of steel. Since there had been no standardized tests and since the tests are desirable to give a measure of the comparative effectiveness of various insulating coatings and to insure that resistance between sheets in a laminated core will not permit sufficient induced currents to flow between laminations so as to affect materially the core losses, the development of this test is important.

Ferro-Alloys

Notable accomplishments were made in the work on ferro-alloys during the past year through the work of Committee A-9 which completed extensive revisions of nine standard specifications covering the various ferro-alloys. The revisions were issued in the form of new tentative specifications which when adopted will replace the standards. The new requirements are in closer agreement with commercial practice and it is believed they will be of much greater service to industry. The specifications cover ferrochromium, ferromanganese, ferromolybdenum, ferrosilicon, ferrotungsten, ferrovanadium, molybdenum salts and compounds, and spiegeleisen.

Iron-Chromium-Nickel Alloys

Several active projects are under way. One of considerable interest involves the collection and the tabulation of data on chemical compositions, physical and mechanical properties, and corrosion-resistant properties of corrosion-resistant and heat-resistant alloys. Eight groups have been soliciting data which are being recorded on special forms preparatory to their review by the committee for publication. Active consideration is being given to methods of corrosion testing and "A Guide for Conducting Plant Corrosion Tests" has been drafted for consideration by Committee A-10.

Several inspections of architectural installations of stainless steel have been made. When additional information and data result from further work, a report is planned. Progress was made in developing fundamental data on elastic properties of alloys in the committee field. Further work is contemplated. In the program on metallographic testing, a study is being made of the effect of heating between 400 and 900 C. on the nature of the carbide precipitate. Two of the cooperating laboratories reported a duplex structure on the samples of the 18-8 alloy heated to 750 C.

Effect of Temperature on Metals

The Joint A.S.M.E.-A.S.T.M. Research Committee on the Effect of Temperature on the Properties of Metals has been most active. Perhaps the most important feature of its extensive report (70 pages) presented at the 1938

A.S.T.M. annual meeting concerned the sponsored research at Battelle Memorial Institute, known as Project No. 18, and dealing with the effect of some manufacturing variables on the creep behavior of several steels. Worthy of special mention also was the revision along broader lines of the tentative test for long-time (creep) high-temperature tension tests (E 22). The committee also completed another very important project (No. 11) covering the collection of all available creep data on ferrous and non-ferrous materials into a single publication. This was a sponsored research at the University of Michigan, under Dr. C. L. Clark, and under the direction of a subcommittee headed by Mr. P. E. McKinney. The completed report now on sale by the two sponsor societies comprises 864 pages, with 273 curves and 37 tables. It is recommended to all who are interested in any way in creep at high temperatures.

At the recent A.S.M.E. meeting, two other projects were covered in reports—one on "Creep in Tubular Pressure Vessels," by Dr. F. H. Norton, covered the sponsored research, known as Project No. 10, at Massachusetts Institute of Technology, on carbon-molybdenum and 5 per cent chromium-molybdenum steel tubular specimens at temperatures of 800-1050-1200 F. The second report on "The Resistance to Relaxation of Materials at High Temperatures" by E. L. Robinson, General Electric Co., covers the studies and tests carried out as Project No. 16; and brings the feature of relaxation tests into open consideration. When published, these reports will be of interest to many. The committee hopes to carry out further work on Project No. 10 in the near future.

The work on Project No. 15 "Torsion Tests for Comparison with Tension Tests on a Carbon-Molybdenum Steel" and Project No. 17 "Acceptability Tests for High-Temperature Characteristics" has now been completed and the reports are before the committee for study. They will no doubt be included in the committee's report next June.

The committee has decided to direct attention again to the effect of low temperatures on metals, and as part of its studies in Project No. 13 expects to hold a round table discussion next June, in Atlantic City, dealing with experiences and problems at low temperature, materials for such service, and testing methods with such service in mind. The plans are in charge of F. B. Foley.

The committee has decided to continue further in Project No. 18, dealing with the effect of manufacturing variables and their effect on creep. The effect of deoxidation practices and related grain structures will next be examined, the work continuing at Battelle under Dr. H. W. Gillett. Later, it is expected that carbon content and grain structure will be studied.

Fatigue of Metals

The Research Committee on Fatigue of Metals is conducting a research to determine whether the shape of the stress-cycle (*S-N*) diagram and the endurance limit determined from it indicate a property of the metal tested, or whether they are affected by the type of testing machine used, and if so, how much they are affected.

Studies are in progress on two typical steels, a heat-treated alloy steel and an "as rolled" low-alloy steel. Tests are being made on rotating-beam machines with two symmetrical loads (R. R. Moore type), on rotating-cantilever fatigue machines, on tension-compression fatigue machines (Haigh electromagnetic type) and on deForest magnetic vibration machines ("Raflex" type). Cooperating agencies include: Timken Roller Bearing Co., American Chain and Cable Co., American Steel Foundries, National Bureau of Standards, Westinghouse Research Labs., U. S. Naval Engineering Experiment Station, Massachusetts Institute of Technology, Wright Field Laboratories of the U. S. Air Service, American Rolling Mill Co., and the U. S. Naval Aircraft Factory at Philadelphia.

Copper Wires for Electrical Conductors

Committee B-1 on Copper and Copper Alloy Wires for Electrical Conductors developed a number of revisions in its standards and tentative standards, all of which were adopted. Various changes were itemized in the report. One of the modifications included the addition of notes defining speed of tension testing in terms of speed of moving head under unloaded conditions in inches per minute, and without reference to length of sample. The committee felt it desirable to get these recommendations before the industry at the earliest possible moment, pending more complete determinations of desirable limitations, which work is under way. Users of certain types of wire, particularly soft drawn wire and rectangular wire are being asked to comment on the packaging requirements of specifications. Other problems being studied involve dimensional tolerances and length of lay for concentric lay cable.

Non-Ferrous Metals and Alloys; Corrosion

In addition to new specifications giving standardized requirements for the first time for electrolytic cathode copper, the Society's Committee B-2 on Non-Ferrous Metals and Alloys submitted important revisions in the standards covering phosphor tin, phosphor copper, silicon copper, and brazing solder, these being acted upon at the E-10 meeting in August. Proposed changes include the addition to the silicon copper specifications of two classes involving silicon content of 17 to 21, and 28 to 32 per cent, respectively.

An active group is studying copper-bearing lead for the manufacture of sheath for electric cables and the solder metal specifications (B 32) are under study, particularly, as to the effect of bismuth on which information is not well defined. There has been prepared by this group a draft of proposed requirements for nickel-copper alloy, plates, sheets and strips. When issued, this specification will be of considerable interest to users of monel metal.

Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys is continuing its efforts to write a satisfactory recommended practice for the spray test.

The report of the subgroup on atmospheric corrosion which has been made available during the year presents the results of the third series of tests made on 24 non-ferrous metals and alloys exposed in 1931 to various atmospheres at nine test locations. These data included in the 20-page report of Subcommittee VI will be of great value to those concerned with non-ferrous metals and alloys. The program of the subcommittee contemplates making five such tests at various intervals of time over a 25-year period. In all, three

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Comparison of Standard Tests on Building Brick by Two Laboratories

By W. J. Krefeld[1] and J. W. McBurney[2]

Prefatory Abstract.—For the purpose of determining whether the current Standard Methods for Testing Brick (C 67 – 37) describe the techniques of testing brick in sufficient detail so that two laboratories working independently on the same or comparable samples would be in essential agreement, the National Bureau of Standards and the Engineering Materials Laboratory of Columbia University conducted a joint investigation on brick testing, using samples in part comparable and in part identical. It is concluded that the current water-absorption tests are of satisfactory accuracy and reproducibility. The compressive strength test is unsatisfactory in comparison with the water-absorption test.

RESULTS of repeated water-absorption tests by the same operator on the same specimens of building bricks had been previously reported.[3] These tests demonstrated that the then current Standard Methods of Testing Brick (C 67 – 31)[4] were defective in that they did not sufficiently describe and establish the techniques necessary for reproducibility. This paper attempts to answer the question: Do the current Standard Methods of Testing Brick C 67–37[5] describe the techniques of testing brick in sufficient detail so that two laboratories working independently on the same or comparable samples will be in essential agreement?

DESCRIPTION OF PROGRAM

Through Mr. J. H. Hansen, Executive Secretary of the Brick Manufacturers Association of New York, arrangements were made between the Civil Engineering Research Laboratories of Columbia University and the National Bureau of Standards as follows:

1. Mr. Hansen selected 30 whole bricks at the plant of one of the Hudson Valley Brick Manufacturers, which were sound, "hard and well burned" and, in so far as could be judged by visual inspection and position in the kiln, of equal degree of firing. These 30 bricks were numbered from 1 to 30, wrapped separately and divided at random into two equal samples referred to hereafter as samples No. 1 and No. 2. Sample No. 1 was sent to one of the cooperating laboratories referred to hereafter as laboratory A. Laboratory B received sample No. 2.

2. Each laboratory determined water absorption by 24-hr. cold immersion and by 5-hr. boiling on the 15 whole bricks. Overnight cooling was used for the 5-hr. boiling test.

3. The flexural strength (modulus of rupture) was determined on both samples after drying.

4. Water absorption by 24-hr. cold immersion and by 5-hr. boiling was redetermined on both sets of halves resulting from the flexure test. Forced cooling in 1 hr. was used for the 5-hr. boiling test on one set of halves, hereinafter called the first set. Cooling overnight was used for the second set of halves.

5. Compressive strength, flatwise, was determined on the dried halves constituting the first set and the second set of halves was exchanged with the cooperating laboratory.

6. Both laboratories determined water absorption by 24-hr. cold immersion and by 5-hr. boiling (cooling overnight) on these exchanged halves, and then measured compressive strength on the specimens after drying.

The only instructions were that both laboratories should use the procedures outlined in Methods C 67 – 37. No consultation or correspondence took place between the laboratories on the subject of procedures until after completion of all tests. Each laboratory completed its tests and submitted its report to Mr. Hansen without knowledge of the results obtained by the other.

PRESENTATION OF DATA

Table I presents the data on sample No. 1 and Table II on sample No. 2. The saturation coefficients[6] given in Table III are calculated from the data of Tables I and II.

DISCUSSION OF DATA

The analysis of these data indicates differences in test results due to random variations in the sample, differences between halves of the same brick, and differences attributable to testing technique and procedure. The program afforded comparison of test results on random samples from one lot and, in the case of water absorption, of tests on identical samples by both laboratories. In the following discussion summarizing the analysis, the various tests are referred to by the column numbers indicated in Tables I and II, which also serve to differentiate tests made by the two laboratories. Comparisons of the water-absorption test are shown in Tables IV and V.

1. *Comparisons of Samples Nos. 1 and 2:*

Although samples Nos. 1 and 2 represent a random separation of a single sample selected for its uniformity, the differences between samples Nos. 1 and 2 are consistent and exceed the error of the water-absorption measurements. The differences include: (1) The mean absorption of sample No. 2 exceeds the mean absorption of sample No. 1 in all

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication, or for the attention of the author. Address all communications to Society Headquarters.

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[3] J. W. McBurney, "Water Absorption of Building Brick," *Proceedings*, Am. Soc. Testing Mats., Vol. 36, Part I, p. 260 (1936).

[4] Standard Methods of Testing Brick (Compression, Flexure, Absorption) (C 67 – 31) 1936 Book of A.S.T.M. Standards, Part II, p. 140.

[5] Standard Methods of Testing Brick (Modulus of Rupture, Compressive Strength, Absorption) (C 67 – 37), 1937 Supplement to Book of A.S.T.M. Standards, p. 78.

[6] These saturation coefficients are what have been heretofore referred to as "*C/B* ratios." The expression "saturation coefficient" is recommended by the Building Research Board of Great Britain (see p. 22, Report of Building Research Board for the year 1937). Committee C-15 on Manufactured Masonry Units has taken formal action to replace the term "*C/B* ratio" by "saturation coefficient" in the standards coming under its jurisdiction.

TABLE I.—RESULTS OF TESTS ON BRICKS OF SAMPLE NO. 1

Specimen	Water Absorption, per cent								Strength, lb. per sq. in.		
	24-hr. Cold Immersion				5-hr. Boiling						
		Half Specimen				Half Specimen				Compression	
	Whole Specimen, Tested by Lab. A	First Set, Tested by Lab. A	Second Set, Tested by Lab. A	Second Set, Tested by Lab. B	Whole Specimen, Tested by Lab. A	First Set, Tested by Lab. A	Second Set, Tested by Lab. A	Second Set, Tested by Lab. B	Modulu of Rupture, Tested by Lab. A	First Set, Tested by Lab. A	Second Set, Tested by Lab. B
	1a	*2a*	*3a*	*4a*	*5a*	*6a*	*7a*	*8a*	*9a*	*10a*	*11a*
No. 1	16.3	16.3	16.9	16.8	20.5	20.7	21.2	21.1	975	5110	5015
No. 3	15.0	15.3	15.7	15.6	19.9	20.2	20.3	20.2	940	5320	5090
No. 4	16.2	16.2	16.7	16.6	20.5	20.8	20.9	20.9	895	4350	5015
No. 6	16.2	16.4	16.5	16.4	20.8	21.0	21.2	21.1	895	4570	4965
No. 7	15.0	15.0	15.9	15.6	19.7	19.8	20.4	20.1	1015	5230	5340
No. 8	16.2	16.6	16.4	16.3	20.6	21.3	20.5	20.5	890	4220	5180
No. 18	17.1	17.3	17.4	17.3	21.2	21.5	21.5	21.4	785	4650	5345
No. 19	14.6	14.6	15.0	14.9	19.1	19.4	19.4	19.3	1120	5350	5850
No. 20	14.3	14.5	14.6	14.6	19.1	19.5	19.3	19.3	990	5100	6455
No. 21	17.9	18.4	17.8	17.6	22.1	22.6	22.1	21.9	470	3310	4200
No. 24	16.4	16.6	16.2	16.0	20.4	20.8	20.9	20.8	890	5020	6355
No. 25	14.8	14.8	15.1	15.0	19.3	19.4	19.6	19.4	970	4940	5730
No. 27	15.1	14.9	15.6	15.6	19.8	20.0	20.2	20.3	910	5480	5380
No. 28	16.6	16.8	16.2	16.1	20.7	21.2	20.7	20.6	960	4990	5650
No. 29	16.4	16.4	16.1	15.9	20.4	20.7	20.7	20.5	815	4730	5450
Mean	15.87	16.01	16.14	16.02	20.27	20.59	20.59	20.49	901	4829	5661
Maximum	17.9	18.4	17.8	17.6	22.1	22.6	22.1	21.9	1120	5480	6990
Minimum	14.3	14.5	14.6	14.6	19.1	19.4	19.3	19.3	470	3310	4200
Standard Deviation	1.02	1.12	0.86	0.85	0.81	0.89	0.78	0.76	144	552	718
Coefficient of Variation, per cent	6.4	7.0	5.3	5.3	4.0	4.3	3.8	3.7	16.0	11.4	12.7

of the eight tests. The difference between the averages for all tests is 0.46 per cent; the largest difference is 0.79 per cent and the smallest 0.17 per cent. (2) The range between the individual maximum and minimum absorption values for specimens of sample No. 1 is greater in each of the eight absorption tests than is the corresponding range for sample No. 2. The mean difference between maximum and minimum absorption for sample No. 1 is 3.2 per cent, and for sample No. 2, 1.5 per cent. This difference in range and distribution is also demonstrated by the high standard deviations and coefficients of variation of sample No. 1 compared with sample No. 2. Although the mean absorption of sample No. 2 is higher than that of sample No. 1 in 6 out of 8 tests, the individual maximum of sample No. 1 exceeds the individual maximum of sample No. 2. In one test they agree, and in one test the individual maximum of sample No. 2 exceeds that of sample No. 1 by 0.1 per cent. That sample No. 1 is "harder burned" than sample No. 2 is also indicated by comparison of their moduli of rupture. Laboratory B confirms this difference by its difference in compressive strengths of the two samples. Laboratory A showed no essential difference in compressive strength between samples Nos. 1 and 2. This will be discussed under "Strength Tests."

TABLE II.—RESULTS OF TESTS ON BRICKS OF SAMPLE NO. 2

Specimen	Water Absorption, per cent								Strength, lb. per sq. in.		
	24-hr. Cold Immersion				5-hr. Boiling						
		Half Specimen				Half Specimen				Compression	
	Whole Specimen, Tested by Lab. B	First Set, Tested by Lab. B	Second Set, Tested by Lab. B	Second Set, Tested by Lab. A	Whole Specimen, Tested by Lab. B	First Set, Tested by Lab. B	Second Set, Tested by Lab. B	Second Set, Tested by Lab. A	Modulus of Rupture, Tested by Lab. B	First Set, Tested by Lab. B	Second Set, Tested by Lab. A
	1b	*2b*	*3b*	*4b*	*5b*	*6b*	*7b*	*8b*	*9b*	*10b*	*11b*
No. 2	15.7	16.0	15.9	15.5	20.7	21.3	20.7	20.2	538	4365	5620
No. 5	15.0	16.3	16.4	16.1	20.7	21.3	20.8	20.5	802	5095	5090
No. 9	16.9	16.9	17.3	17.0	21.3	21.7	21.5	21.2	568	9710	4430
No. 10	16.0	16.4	16.1	15.9	20.8	21.2	20.6	20.3	755	5080	5830
No. 11	16.8	16.8	17.1	17.0	21.1	21.5	21.3	21.0	683	4615	4660
No. 12	16.3	16.5	16.7	16.5	20.5	20.8	20.6	20.5	608	4910	4760
No. 13	16.8	16.2	17.8	17.7	21.2	21.2	21.6	21.5	818	5105	4700
No. 14	16.4	15.7	17.4	17.3	20.8	20.7	21.4	21.0	726	5485	4830
No. 15	16.5	16.4	16.5	16.4	20.2	20.4	20.3	20.0	449	5150	5290
No. 16	16.5	16.1	17.0	16.8	20.9	21.0	20.9	20.8	600	4160	4620
No. 17	16.5	16.5	17.1	17.0	21.0	21.2	21.1	21.1	834	4870	4500
No. 22	16.7	16.6	17.1	17.0	21.3	21.5	21.5	21.3	740	5050	4660
No. 23	16.2	15.8	16.8	16.6	20.8	21.2	21.0	20.8	819	4800	5030
No. 26	16.1	16.1	16.4	16.1	20.9	21.4	20.9	20.6	764	5280	5750
No. 30	16.5	16.4	16.6	16.4	21.0	21.2	21.1	20.9	628	5170	4340
Mean	16.39	16.31	16.81	16.62	20.88	21.17	21.02	20.78	689	4923	4940
Maximum	16.9	16.9	17.8	17.7	21.3	21.7	21.6	21.5	834	5485	5830
Minimum	15.7	15.7	15.9	15.5	20.2	20.4	20.3	20.0	449	4160	4340
Standard Deviation	0.34	0.34	0.51	0.59	0.29	0.33	0.45	0.43	118	349	481
Coefficient of Variation, per cent	2.1	2.1	3.0	3.5	1.4	1.6	2.1	2.1	17.1	7.1	9.7

TABLE III.—SATURATION COEFFICIENTS OF BRICKS OF SAMPLES NOS. 1 AND 2

Sample No. 1					Sample No. 2				
Specimen	Whole Specimen, Tested by Lab. A	Half Specimen			Specimen	Whole Specimen, Tested by Lab. B	Half Specimen		
		First Set, Tested by Lab. A	Second Set, Tested by Lab. A	Second Set, Tested by Lab. B			First Set, Tested by Lab. B	Second Set, Tested by Lab. B	Second Set, Tested by Lab. A
	Ratio, *1a* to *5a*	Ratio, *2a* to *6a*	Ratio, *3a* to *7a*	Ratio, *4a* to *8a*		Ratio, *1b* to *5b*	Ratio, *2b* to *6b*	Ratio, *3b* to *7b*	Ratio, *4b* to *8b*
No. 1	0.795	0.787	0.797	0.796	No. 2	0.758	0.751	0.768	0.767
No. 3	0.754	0.757	0.773	0.772	No. 5	0.773	0.765	0.788	0.785
No. 4	0.790	0.779	0.799	0.794	No. 9	0.793	0.779	0.805	0.802
No. 6	0.779	0.781	0.778	0.777	No. 10	0.769	0.774	0.782	0.783
No. 7	0.761	0.758	0.779	0.776	No. 11	0.796	0.781	0.803	0.809
No. 8	0.786	0.779	0.800	0.795	No. 12	0.795	0.793	0.811	0.805
No. 18	0.807	0.805	0.809	0.808	No. 13	0.792	0.764	0.824	0.823
No. 19	0.764	0.752	0.773	0.772	No. 14	0.788	0.758	0.813	0.823
No. 20	0.749	0.744	0.756	0.756	No. 15	0.817	0.804	0.813	0.820
No. 21	0.810	0.814	0.805	0.804	No. 16	0.789	0.767	0.813	0.808
No. 24	0.804	0.798	0.775	0.769	No. 17	0.786	0.778	0.810	0.806
No. 25	0.767	0.763	0.770	0.773	No. 22	0.784	0.772	0.795	0.798
No. 27	0.763	0.745	0.772	0.768	No. 23	0.779	0.745	0.800	0.798
No. 28	0.802	0.792	0.783	0.782	No. 26	0.770	0.752	0.785	0.782
No. 29	0.804	0.792	0.778	0.776	No. 30	0.786	0.774	0.787	0.785
Mean	0.782	0.776	0.783	0.781		0.785	0.770	0.800	0.800
Maximum	0.810	0.814	0.809	0.808		0.817	0.804	0.824	0.823
Minimum	0.749	0.744	0.756	0.756		0.758	0.745	0.768	0.767
Standard Deviation	0.021	0.022	0.015	0.014		0.013	0.016	0.015	0.016
Coefficient of Variation, per cent	2.7	2.8	1.9	1.8		1.7	2.0	1.9	2.1

2. *Comparison of Half Bricks:*

From the nature of the clay and the method of processing, differences in the absorptions of the two halves of the same brick would be expected. That such differences exist is confirmed by the following observations: (1) The poorest correlation for all of the absorption comparisons is shown between the first and second set of halves of the same sample tested by the same laboratory. Note the correlation of column *2a* with column *3a*, *6a* with *7a*, *2b* with *3b*, and *6b* with *7b*. In the case of *2b* with *3b*, the correlation is so poor that it might be suspected that laboratory B had mixed the order of the specimens. (2) The agreement of the absorptions of the whole brick specimens in general is better with the averages of the two halves than with either half brick individually. (3) The randomness of the relations between the halves of the same bricks is shown by the "mean difference" exceeding the "difference in mean" for the comparisons listed under (1) above. Since the distributions of the two sets of halves are random between the two samples, it would be expected that the "difference in mean" would be small since the random differences between the halves would tend to cancel each other. Much of the "difference in mean" can probably be ascribed to systematic difference in testing. In so far as agreement between absorption tests is judged upon the basis of correlation between the individual test specimens, it is concluded that testing the two sets of halves of the same bricks introduces a random difference in the specimens. Other clays and other methods of manufacture may largely eliminate this difference.

3. *Water Absorption by 24-hr. Cold Immersion:*

In the two preceding sections, the question of differences in samples as effecting differences in results has been considered. Tests *3a* and *4a* were made on identical specimens and by the same techniques, subject to the interpretations of the two laboratories. The same statement applies to tests *3b*

TABLE IV.—COMPARISONS OF WATER-ABSORPTION TEST

Tests Compared	Difference in Mean	Mean Difference	Standard Deviation of Difference from Mean Difference	Coefficient of Correlation, r	Coefficient of Alienation $\sqrt{1-r^2}$
SAMPLE NO. 1					
1a and *2a*	0.14	0.16	0.15	0.990	0.143
1a and *3a*	0.27	0.40	0.20	0.934	0.358
1a and mean of *2a* and *3a*	0.20	0.23	0.12	0.985	0.171
2a and *3a*	0.13	0.41	0.23	0.918	0.396
3a and *4a*	0.12	0.12	0.07	0.996	0.085
5a and *6a*	0.32	0.32	0.16	0.986	0.164
5a and *7a*	0.32	0.33	0.20	0.959	0.282
5a and mean of *6a* and *7a*	0.32	0.32	0.07	0.996	0.085
6a and *7a*	0.00	0.27	0.24	0.910	0.414
7a and *8a*	0.10	0.11	0.08	0.992	0.128
SAMPLE NO. 2					
1b and *2b*	0.08	0.24	0.22	0.543	0.840
1b and *3b*	0.42	0.42	0.28	0.837	0.547
1b and mean of *2b* and *3b*	0.17	0.18	0.10	0.944	0.330
2b and *3b*	0.50	0.55	0.50	0.127	0.992
3b and *4b*	0.19	0.19	0.09	0.991	0.131
5b and *6b*	0.29	0.31	0.18	0.795	0.607
5b and *7b*	0.14	0.17	0.15	0.887	0.463
5b and mean of *6b* and *7b*	0.22	0.22	0.08	0.963	0.271
6b and *7b*	0.15	0.30	0.22	0.535	0.845
7b and *8b*	0.24	0.24	0.13	0.954	0.300

TABLE V.—COMPARISON OF SATURATION COEFFICIENTS

Tests Compared	Difference in Mean	Mean Difference	Standard Deviation of Difference from Mean Difference	Coefficient of Correlation, r	Coefficient of Alienation $\sqrt{1-r^2}$
SAMPLE NO. 1					
Ratio:					
1a to *5a* and *2a* to *6a*	0.006	0.007	0.0045	0.960	0.821
1a to *5a* and *3a* to *7a*	0.001	0.011	0.0087	0.712	0.702
1a to *5a* and mean of *2a* to *6a* and *3a* to *7a*	0.002	0.006	0.0066	0.920	0.393
2a to *6a* and *3a* to *7a*	0.007	0.015	0.0072	0.728	0.686
3a to *7a* and *4a* to *8a*	0.002	0.002	0.0018	0.992	0.128
SAMPLE NO. 2					
Ratio:					
1b to *5b* and *2b* to *6b*	0.015	0.015	0.0092	0.755	0.655
1b to *5b* and *3b* to *7b*	0.015	0.015	0.0083	0.792	0.610
1b to *5b* and mean of *2b* to *6b* and *3b* to *7b*	0.001	0.004	0.0032	0.927	0.375
2b to *6b* and *3b* to *7b*	0.030	0.030	0.0166	0.390	0.921
3b to *7b* and *4b* to *8b*	0.000	0.004	0.0025	0.959	0.281

and *4b* on sample No. 2. Elimination of differences resulting from differences in the samples would be expected in the comparison of *1a* with the mean of *2a* and *3a* and *1b* with the mean of *2b* and *3b*, since the two sets of halves used for tests *2* and *3* together make the sample of whole bricks used for test *1*. These tests on identical specimens are characterized by low differences in means (0.12 to 0.20 per cent), mean differences the same or but slightly exceeding the differences in mean, rather small standard deviations of the difference from the mean difference and high coefficients of correlation (see Table IV). This indicates that the differences may be ascribed to systematic rather than random error. For the mean difference to have the same magnitude as the difference in mean requires that the signs of the individual difference all be the same.

The weighings of both laboratories were accurate to not better than plus or minus 0.5 g., which renders uncertain the 0.1 per cent accuracy of the weighings on the half brick which averaged 900 g. in weight. The maximum difference in dry weight between tests *3a* and *4a* was 2.0 g. and between tests *3b* and *4b* was 1.5 g. In practically every case the second weighing was the lower.

Table VI presents the data on temperatures used in the 24-hr. cold-immersion test. Laboratory B did not record changes in temperature (if any) during the progress of the 24-hr. cold-immersion test. It is known that apparent absorption by immersion is affected by the temperature of the water bath. The reason for this is obvious from the law of Gay-Lussac. If any improvement in accuracy of the 24-hr. cold-immersion test for absorption is sought, closer control of temperature will be necessary. Method C 67 – 37 provides "When cool, the specimens shall be weighed . . . The dry specimen shall be immediately submerged . . . " Both laboratories followed the practice of exposing the bricks in air at room temperature overnight before starting the 24-hr. submersion test. For the benefit of possibly careless operators intent upon reducing the time of the test, it would appear advisable to add to this section of Methods C 67 – 37 a statement to the effect that the bricks should be cooled to the temperature specified for the bath before immersion.

4. *Water Absorption by 5-hr. Boiling:*

As in the 24-hr. cold-immersion test, the best correlation was found on the identical specimens tested by both laboratories. Good correlation also existed between the results on the whole brick compared with the mean for the two half bricks. Tests *6* and *7*, though in good agreement (no difference between *6a and 7a*) for their means, correlated poorly. This large random deviation is confirmed by their large mean difference and large standard deviation of difference from the mean difference. The agreement in general is better than had been expected, since tests *6* and *7* involve different methods of cooling after boiling.

Laboratory A reported temperature of tank at start of weighing as follows: Test *5a*, 24 C. (75 F.); *6a* (forced cooling), 10 C. (50 F.); *7a*, 24 C. (75 F.), and *8b*, 18 C. (64.5 F.). Test *6a* is below the temperature limit specified by Methods C 67 – 37. Except for test *7b*, 22 C. (72 F.). laboratory B did not report the temperature to which cooling took place.

5. *Saturation Coefficient:*

Again the agreement between the two laboratories testing identical specimens was better than that obtained by either laboratory testing the two halves of the same brick. The agreement between results on the whole bricks and the mean of the two sets of halves was very good. That the saturation coefficients appear subject to less error than the absorption may be explained by the tendency of a deviation in the 24-hr. cold-absorption test to also affect the 5-hr. boiling test in the same direction (see Table V).

6. *Strength Tests:*

The coefficients of variation of the results of the compressive and flexual strength tests are from two to eight times those of the absorption tests. The best correlation (0.844) was between the moduli of rupture and the compressive strengths determined on sample No. 1 and made by laboratory A. The correlation between the corresponding tests

TABLE VI.—TEMPERATURE RECORDS ON 24-HR. COLD-IMMERSION TEST

Test	Laboratory	Temperature			
		At Start		At End	
		deg. Cent.	deg. Fahr.	deg. Cent.	deg. Fahr.
1a	A	18	64.5	18.5	65
2a	A	16	61	18	64.5
3a	A	16	61	18	64.5
4a	B	22	72	22	72
1b	B	21	70	21	70
2b	B	22	72	22	72
3b	B	23	73	23	73
4b	A	22	71.5	20	68

made by laboratory B on sample No. 2 was 0.337. The correlation between both laboratories' results on compressive strength tests on sample No. 1 was 0.642. The corresponding correlation on sample No. 2 was 0.187 which is almost random correlation. Negative correlations of from —0.710 to —0.790 represent the agreement between compressive strength and water absorption determined by laboratory A. Corresponding correlations for the same tests made by laboratory B scatter widely, going as low as —0.150.

It is concluded that laboratory A was less subject to random variation in compressive strength test than laboratory B. On the other hand, laboratory A must have been subject to a considerable systematic error in reporting *10a*. That the nature and technique of capping brick specimens will materially affect the results of compressive strength test is well known. In general, the stronger the capping material, the higher the brick strength. The highest strengths are obtained when capping is eliminated entirely and the brick specimen is prepared by grinding and polishing the bearing faces into smooth parallel planes preparatory to testing. The fact that laboratory A changed its supply of plaster of Paris for capping between tests *10a* and *11b* therefore supplies one possible explanation of this systematic error.

The test procedure and equipment used by each laboratory in conducting the compression tests may be of interest in connection with further studies. Laboratory A reported a maximum thickness of 1/8 in. and B an average thickness of approximately 1/16 in. for plaster of Paris caps. A 300,000-lb. Southwark-Emery (hydraulic) and a 200,000-lb. Riehle (3-screw) testing machine were used by laboratories A and B, respectively. Both laboratories supported the brick on heavy bearing blocks not less than 6 in. in thickness. The rate of loading reported by laboratory A was 30,000 lb. per min. A speed of 0.04 to 0.05 in. per min. was used by laboratory B.

A possible significant difference in technique consisted in laboratory B's use of thin sheets of paper between the bearing surfaces of the testing machine and the plaster of Paris capping of the bricks. Laboratory A permitted direct contact between bearing surface and capping. These bearing surfaces were machined planes in both instances.

The authors doubt that repeated boiling and drying had any effect on the compressive strength of these particular bricks.

Obviously, strength tests are relatively erratic and subject to random variations in comparison with absorption tests. This is to be expected from the nature of the test. An absorption test averages the different degrees of porosity in the various portions of the test specimens. A strength test (flexural or compressive) is a measure of the strength of the weakest part of the specimen. The philosophy of this distinction in nature of tests is given in a paper by Preston.[7]

The authors recommend that the sections of Methods C 67 – 37 dealing with the compressive strength test be investigated as a preliminary to revision. Section 11 appears to require elaboration to the end that the reproducibility of the capping be better controlled. Such an investigation should also include a study of methods of filling the "frogs" or depressions characteristically present in soft mud bricks of the type considered in this paper. The use of whole bricks instead of half bricks might improve the reproducibility of the compressive strength test. Since compression tests do not permit the use of identical samples, it is recommended that this investigation be made on samples that are assembled, on the basis of previously determined absorption tests. Each sample should have a mean absorption within two or three tenths of a per cent of the other samples, and should have a similar and comparable distribution of absorptions within the sample.

[7] Frank W. Preston, "Cows and Cracks or Measurements of the Strength of Glassware: Their Difficulties and Meanings," *Bulletin*, Am. Ceramic Soc., Vol. 16, No. 10, pp. 400-402 (1937).

SUMMARY AND CONCLUSIONS

From the results of the cooperative tests by the Civil Engineering Research Laboratories of Columbia University and the National Bureau of Standards on building bricks made in part on a randomly divided sample and in part on identical samples, the following conclusions are considered as justified:

1. Following the procedure of Methods C 67 – 37, the averages on two samples (15 half bricks) differed by 0.12 and 0.19 per cent when tested for water absorption by 24-hr. cold immersion by both laboratories.

2. The corresponding differences for the same samples when tested for water absorption by 5-hr. boiling were 0.10 and 0.24 per cent.

3. The saturation coefficients of the same two samples differed by 0.002 and 0.000 when tested by both laboratories.

4. The difference between the means of all of the absorption tests on each of two samples formed by a random division of a single sample selected for uniformity averaged 0.46 per cent.

5. Random differences exceeding the reproducibility of the absorption test methods were found between the halves from the same brick.

6. Conclusions 4 and 5 can be summarized by stating that the accuracy of the absorption tests exceeded the reproducibility of the samples, unless the samples were identical.

7. Standard Methods of Test C 67 – 37 provide a water-absorption test of satisfactory accuracy and reproducibility. That two laboratories, working independently and without previous comparison of methods, should check each other so closely on identical samples, indicates that methods C 67 – 37 provides sufficiently exact directions for procedure.

8. The accuracy and reproducibility of the compressive strength test is poor in comparison with the absorption test. Random errors of considerable magnitude are apparent and a systematic error caused by difference in strength of capping material is possible.

ACKNOWLEDGMENTS

The authors acknowledge the cooperation of Mr. J. H. Hansen, Executive Secretary of the Brick Manufacturers Association of New York in arranging for these tests. The samples of brick were supplied by the Roseton Brick Corp., Roseton, N. Y. The laboratory tests at the National Bureau of Standards were made by A. R. Eberle, Research Associate for the Structural Clay Products Institute, and by R. H. Brink of the Bureau staff. The corresponding tests at the Civil Engineering Research Laboratories of Columbia University were made by P. H. Ripley of the Laboratory staff.

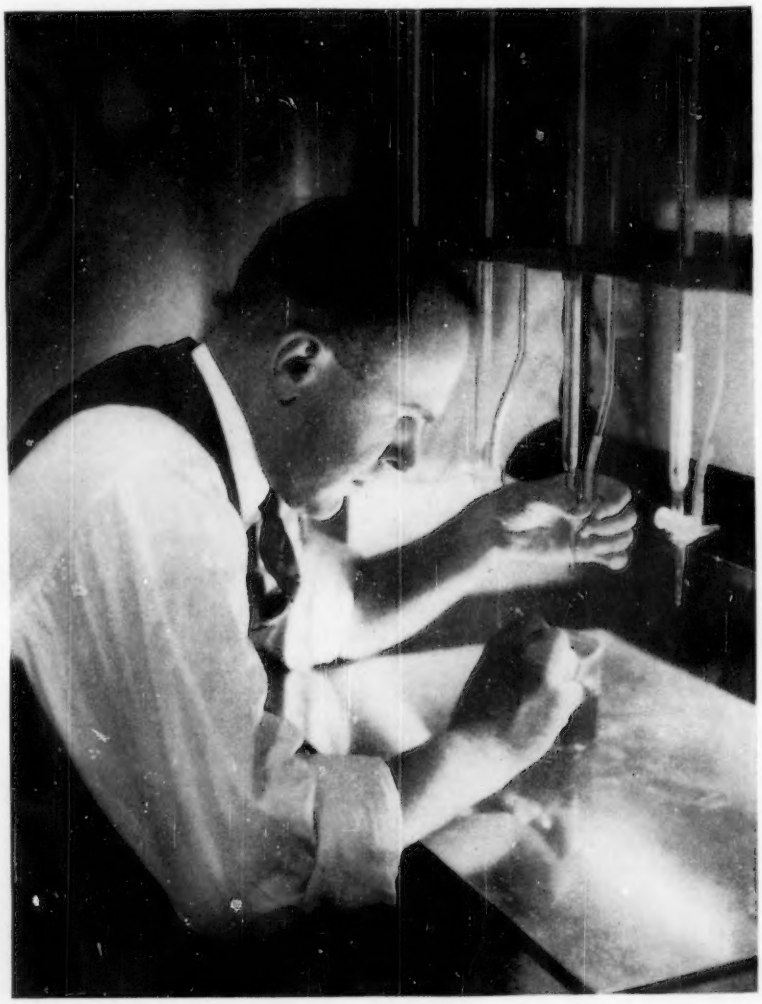
Exhibits at the 1939 Annual Meeting

Two of the features of the Forty-second (1939) Annual Meeting to be held in Atlantic City, June 26 to 30 incl., will be the Fifth Exhibit of Testing Apparatus and Related Equipment and the Second Photographic Exhibit and Competition. As in previous years, the apparatus exhibit will be featured by displays of leading companies in the industry showing latest developments in testing instruments, laboratory supplies and related fields. There will also be research displays sponsored by various committees of the Society and by university and government departments and related research institutions. A number of companies in the apparatus fields have already applied for space and it is expected the commercial section of the exhibit will be a most interesting one.

A special committee is being appointed to develop plans for the second photographic competition. The general theme of this will cover phases of the Society's work, testing and research, and it is expected that the rules will in general follow those in effect last year, but further details of this will be furnished.

Many of those who saw the 1938 display expressed their keen interest and it is suggested that members who are photography "conscious" definitely keep the exhibit in mind since all members of the Society are invited to take part.

It is just one hundred years ago, January 7, 1839, that photography was released to the public. This occurred at a meeting of the French Academic de Sciences. While the inventor, Nicephore Niepce, who discovered photography some 16 years before that, had been dead for five years, his associate Daguerre, perfected the discovery. The latter invented the use of silver iodide which cut very materially the exposure time needed. The astonishing developments in the 100 years of photography are marvelous indeed. High-speed photography, exceedingly sensitive films, high-powered lenses, miniature cameras, and a host of other developments have marked this period, especially in the last few years. Some of the unusual results of photography in the field of testing will be on display during the 1939 Annual Meeting.



"Titration"—photograph by K. L. Herrmann and R. C. Stratton, Travelers Insurance Co., awarded honorable mention in 1938 photographic exhibition.

Cleveland District Committee Meeting

THE meeting sponsored by the Cleveland District Committee on Wednesday evening, November 30, in the Guild Hall, Builders Exchange Building, in Cleveland, was a most successful event. There were about 100 present at the dinner, and the attendance at the technical session was close to 200.

The feature of the evening was a talk by Dr. F. N. Speller, National Tube Co., on "Corrosion of Metals," stressing especially current problems in the corrosion field with information and data on methods of solving the problems, including specific examples. Following Doctor Speller's talk, which was illustrated, there was a lively discussion period. The broad field of corrosion subjects was covered. Interest in the topic was evident from the discussion.

The officers of the Cleveland District Committee, J. H. Herron, chairman, The James H. Herron Co., and A. J. Tuscany, secretary, Tuscany, Turner and Associates, made arrangements for the meeting.

The Cleveland Engineering Society cooperated by extending the local A.S.T.M. members and their guests the use of their lounge, assisted in publicizing the meeting and in other ways.

There was a large representation of A.S.T.M. members among those present and they brought with them a number of associates and friends who were interested in the subject.

Non-Destructive Testing in the United States of America[1]

By H. H. Lester,[2] R. L. Sanford[3] and N. L. Mochel[4]

Part II—Radiographic Methods[5]

EDITOR'S NOTE.—An invitation to the Society from the British Joint Committee on Materials and Their Testing, to arrange for papers on non-destructive testing, so that American thoughts and practices would be covered in the meeting in London, as well as the British and Continental European viewpoints, resulted in assigning this paper to a committee comprising H. H. Lester, R. L. Sanford and N. L. Mochel, Chairman. The section on Radiographic Methods was prepared largely by Dr. Lester; the one on Magnetic and Electrical Methods by Mr. Sanford; and the part on Acoustical and General Methods by Mr. Mochel; but in each case there were suggestions, cooperation, and review by the other members of the committee.

Certain considerations in BULLETIN publication made it desirable to change the order of the parts of the paper as presented at the meeting. The material on magnetic, electrical, acoustical and general methods appeared in the December BULLETIN.

ROUTINE radiographic inspection of castings began in the United States in 1922 with the installation of X-ray equipment at Watertown Arsenal for the examination of products of its own foundry and for the inspection of purchased material. Commercial industry began using the method in 1923 and 1924 for the examination of high-pressure steam valves and fittings and for oil refinery castings. In 1927 the aluminum industry began using it for control tests. The method was applied to the development and control of the welds of welded gun carriages in 1928. This is believed to be the first use of it for routine inspection and control in a weld shop. In 1930 the U. S. Navy accepted welded steam boilers manufactured under radiographic control. In 1931, The American Society of Mechanical Engineers recognized radiographically tested welds for unfired pressure vessels. Since then radiography with X-rays has gone ahead rapidly. In 1931 there was one installation for pressure vessel testing and five for other work, including the examination of castings. In 1936 these numbers had grown to thirty and eighteen, respectively. The latest estimate indicates that pressure vessel manufacturers use fifty-seven installations and there are thirty-one installations devoted to various other applications. Several companies have more than one X-ray installation, one company having seven. Five recent installations use voltages up to 400 kv.p. There are about six commercial testing laboratories that have X-ray equipment. No exact data are at hand regarding the quantity of films used, but it is roughly estimated that there are around 20,000 X-ray exposures made annually.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication, or for the attention of the author. Address all communications to Society Headquarters.

One important paper in the 1936 X-ray Symposium (1)[6] summarized radiography by gamma rays in the United States. In it the author points out that although some work was done in this field by Pilon and Laborde (2) in 1925, the first systematic studies in the method were made and the working out of practical technique was accomplished by Mehl, Barrett and Doan of the U. S. Naval Research Laboratory in 1928 (3, 4). Typical examples are given illustrating the wide variety of structures examined. These include ship castings, valves and fittings for power plants and oil refineries, turbine casings, penstock piping gun carriages, oil refinery towers and others. Complete details of technique are given for the use of the method.

There has been no great change in the situation since Mochel's paper was written. Radium is used principally for the inspection of castings. The U. S. Navy is the principal user. It owns the large total of 2965 mg. of radium divided into eleven units. These are used in various Naval establishments and also in foundries that manufacture on Navy orders. Two or three commercial companies own radium and there is one company that rents radium and radon for industrial radiography.

The situation with regard to the application of radiography to other than metal products has been described in another of the 1936 Symposium papers (5). These applications have included such objects as radio tubes, telephone units, reinforced concrete, built-up mica, plastics, asbestos board, canned food, candy, and even hams. There seems to be a very broad field for such possible uses of the method. As yet routine examinations have been confined to plastic gears and radio and telephone parts.

RADIOGRAPHY IN THE FOUNDRY

A survey conducted in 1938 by C. W. Briggs of the U. S. Naval Research Laboratory for the benefit of the American Foundrymen's Association disclosed, among other things, the fact that only five foundries out of the two hundred and fifty-one approached were using radiography for the development and control of manufacturing processes. Fourteen others come in contact with it through acceptance tests. In the sixteen years that the method has been in industrial use in this country, only 2 per cent of the foundries have adopted it as a production tool and only 8 per cent have had to meet radiographic acceptance tests.

These low percentage figures do not represent lack of interest. They probably do indicate roughly the extent of present practicable applicability.

The method has been found to apply chiefly to three general classes of castings:

1. Castings that have to withstand high stresses or that have highly stressed sections. Cast gun cradles are examples.

2. Castings that may not be highly stressed but whose unexpected failure might cause losses far in excess of the value

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[1] Presented at a meeting in London, England, November 25, 1938, arranged by the British Joint Committee on Materials and Their Testing and held under the auspices of the British Institution of Electrical Engineers.

[2] Senior Physicist, Watertown Arsenal, Watertown, Mass.

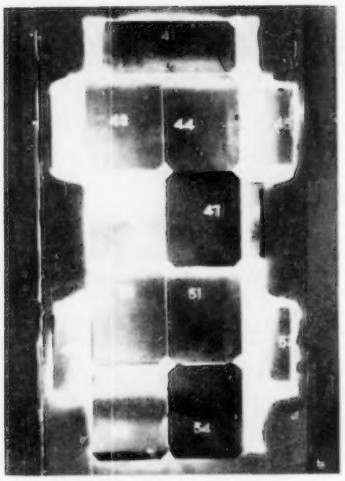
[3] Chief, Magnetic Section, National Bureau of Standards, Washington, D. C.

[4] Metallurgical Engineer, Westinghouse Electric and Manufacturing Co., Philadelphia, Pa.

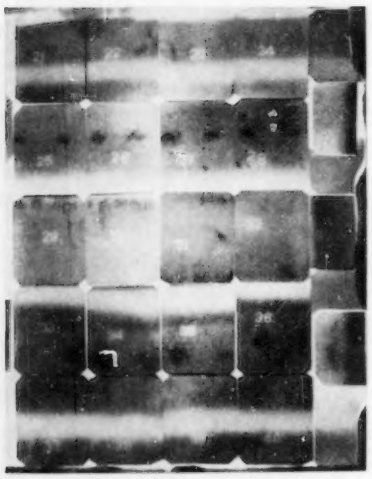
[5] Released for Publication by the Chief of Ordnance of the U. S. Army. Statements and opinions are to be understood as individual expressions of their author and not those of the Ordnance Department.

[6] The numbers in parentheses refer to a list of references appended to this paper, see p. 18.

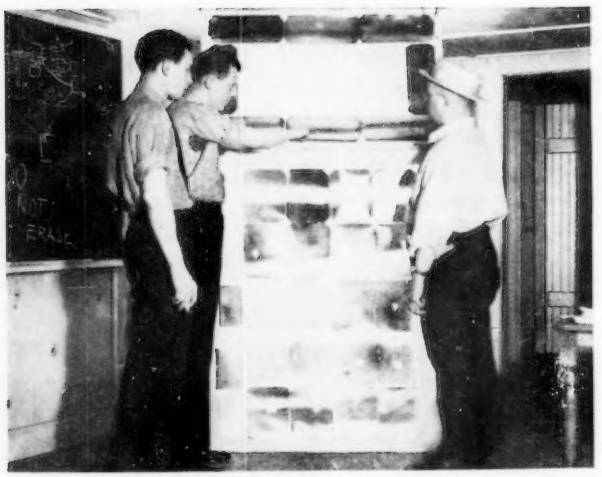
(a) The casting.



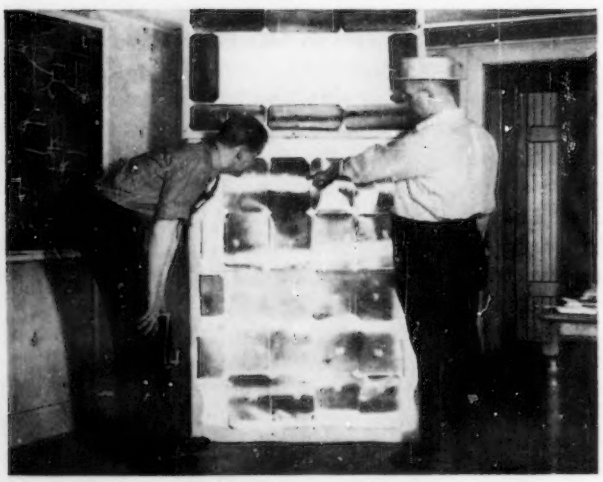
(b) Model with films attached. End view.



(c) Model – side view. Showing porosity conditions.



(d) The laboratory explains to the shop.



(e) The shop explains to the laboratory.

(f) Study.

Fig. 1. – An Example of a Method of Analysis of Radiographic Films.

of the casting. Some aluminum castings that go into airplane constructions, and castings that support the external propeller bearing on some ships, may be cited as examples.

3. Castings that require extensive machining. Some castings used in the construction of gun carriages are illustrative; one casting, for example, costs $1200 to finish machine from the rough, necessary X-ray pictures cost only $28. In some fifty castings examined, there were no rejections but about 60 per cent had defects requiring repair. Many of the castings would have been rejected if the defects had been found in late stages of machining.

Since the majority of castings falls outside of these somewhat narrow groups, there is really only a relatively small percentage of castings to which radiographic study can be applied economically. However, there is a present interest in extending radiographic development to castings where essential soundness may not be mandatory but is desirable. This interest is awakened partly by the growing competition of weldments and other casting substitutes, and the desire on the part of manufacturers to improve their products in a campaign to retain their market.

In Briggs' survey, twenty-seven stated that they hesitated to use radiographic examination because of the cost of equipment and twenty-one because of the cost of radiographic examination. The expense seemed to be the most important deterrent. This is greater than some realize. In straight inspection work, practically the whole cost involved is that of getting the negatives. Where used as a tool in development work the situation is different. One earnest foundry metallurgist remarked in discussing the subject, "It is not the cost of X-raying that bothers us, it is the probable cost of the consequences." In work of this sort negatives are studied very carefully by metallurgists or other highly trained personnel.

Defects are analyzed from the evidence contained in the negatives and from all other known metallurgical facts. Figure 1 is illustrative. In this particular case, a company making heat-treating equipment began a study of certain of its products with the idea that the elimination of porosity known to exist might increase their service life. A casting was X-rayed completely. Because it was scheduled for shipment and could not be held for study, a wooden framework was constructed simulating the shape of the casting. This was covered with translucent cloth and the negative was attached to the model which was illuminated from within. Figure 1 (*a*) shows the casting, (*b*) and (*c*) show two views of the model, (*d*), (*e*) and (*f*) illustrate the cooperative efforts of shop and laboratory in seeking a solution to the problem under study. These pictures were posed at the request of one of the authors but are truly representative of the way this particular company is using radiographic tests. Whether a model is used, or whether the casting is studied directly, the complete utilization of the information contained within the negative involves elaborate and expensive investigation and experimentation. Whether or not the procedure is justified depends upon the value of the results obtained. In most cases, development research does pay fair dividends on a considerable investment.

Another 1938 survey conducted for the benefit of the radiographic committee of the American Society for Testing Materials, to secure evidence as to whether or not there was a general confidence on the part of both producers and consumers in the results of radiographic inspection, revealed that those who have had direct experience with the method, both consumers and producers, have great confidence in it. The preponderance of opinion was to the effect that within the scope of its sensitivity, radiographic tests properly carried out have not failed to reveal existing defects. Various reasons for not using the tests have been based upon lack of familiarity with them, fear of incorrect interpretations by unskilled personnel, distrust of innovations that might mean the adoption of new and unfamiliar standards of soundness, and expense. Probably the cost of testing is the most important item that has prevented wider use of the method.

In one of the recent surveys, opinion was expressed that the use of radiographic tests has not resulted in marked improvement in the quality of castings. This has been the observation of one of the authors in testing purchased material for the Army Ordnance. It has been the experience of another of the authors that some improvement has resulted with some suppliers and little or no improvement with others. It is true that where foundries have only sporadic contacts with radiography through acceptance tests, there has been no particular improvement in casting quality resulting from the tests. On the other hand, where large enough values have been involved to justify the expense of studies to improve foundry procedures, the imposition of radiographic acceptance tests has been successful in bringing about improvements in manufacturing methods. Under these circumstances, the radiographic tests are used really for development and control since the negatives of rejected castings are studied and the results used in making successive attempts at improvement. It is understood that foundries making large castings used by the U. S. Navy have received considerable benefit in this way.

Recent tests described below have demonstrated that gamma graphs are somewhat less sensitive than X-ographs, the test negatives revealing a "cavity" 0.05 in. deep and 0.20 in. in diameter through 3 in. of steel, while X-rays showed under the same conditions of testing a "cavity" 0.03 in. deep and 0.03 in. in diameter. Gamma graphs cannot be relied upon to reveal fine cracks but they are quite sensitive enough to show the porosity conditions that are of most interest to the foundry metallurgist. It is predicted that they will grow in popularity for the testing of large castings partly because large values are involved. The expense of testing is relatively small compared to the value of the casting and the value of the results is correspondingly great. The economy of the tests is more easily demonstrated under such conditions.

RADIOGRAPHY IN THE WELD SHOP

The use of radiographic testing for the routine development and control of industrial welding started in America with its application to fusion welded gun carriages at Watertown Arsenal in 1928. The real impetus to this application came in 1930 with the adoption by the Navy of radiographically inspected welding for steam boilers, and the similar recognition in 1931 by The American Society of Mechanical Engineers in its Boiler Construction Code. Makers of pressure vessels of various kinds very promptly took up welding

and also radiography. The latter has become an essential tool in manufacture.

One of the very great services performed for the testing methods was the defining in the A.S.M.E. Boiler Construction Code of definite standards of soundness to which manufacturers had to build. Porosity conditions were defined by pictures. Rejectable defects such as cracks and unfused regions were specifically designated and tolerable limits were established for slag inclusions. Other provisions had to do with the distance away from the work of the X-ray target, the surface condition of the weld, the type and method of using sensitivity gages, etc.

The original code provisions have undergone revisions and are still being revised, but they introduced definiteness into radiographic testing and did much to remove one of the most important objections to the method, the dependence of interpretation on the personal estimation of an individual. In 1935, the Bureau of Engineering of the U. S. Navy established radiographic standards for Class A-1 welds for its own work. These are defined by eighteen type pictures covering the range of acceptable and non acceptable conditions. The Navy standards of porosity have been ". . . adopted for the A.S.M.E. and for the Joint A.S.M.E.-A.P.I. Construction Codes for Unfired Pressure Vessels. . . ." Figure 2 illustrates one of these standards showing the limit of allowable porosity in Class A-1 welds.

While the standards referred to above have been of great assistance and are, no doubt, the best that could be made at the time, they are not regarded as perfect. They were chosen arbitrarily because there are no reliable data on the physical importance of defects seen in radiographic negatives. Cracks and cracklike defects are, of course, causes for rejection but it is not known how seriously various porosity conditions affect physical properties. These are selected as representing the highest soundness characteristics from the standpoint of porosity that is commercially practicable. An investigation of the problem of the evaluation of physical defects is now being undertaken through cooperative effort of interested industrial societies.

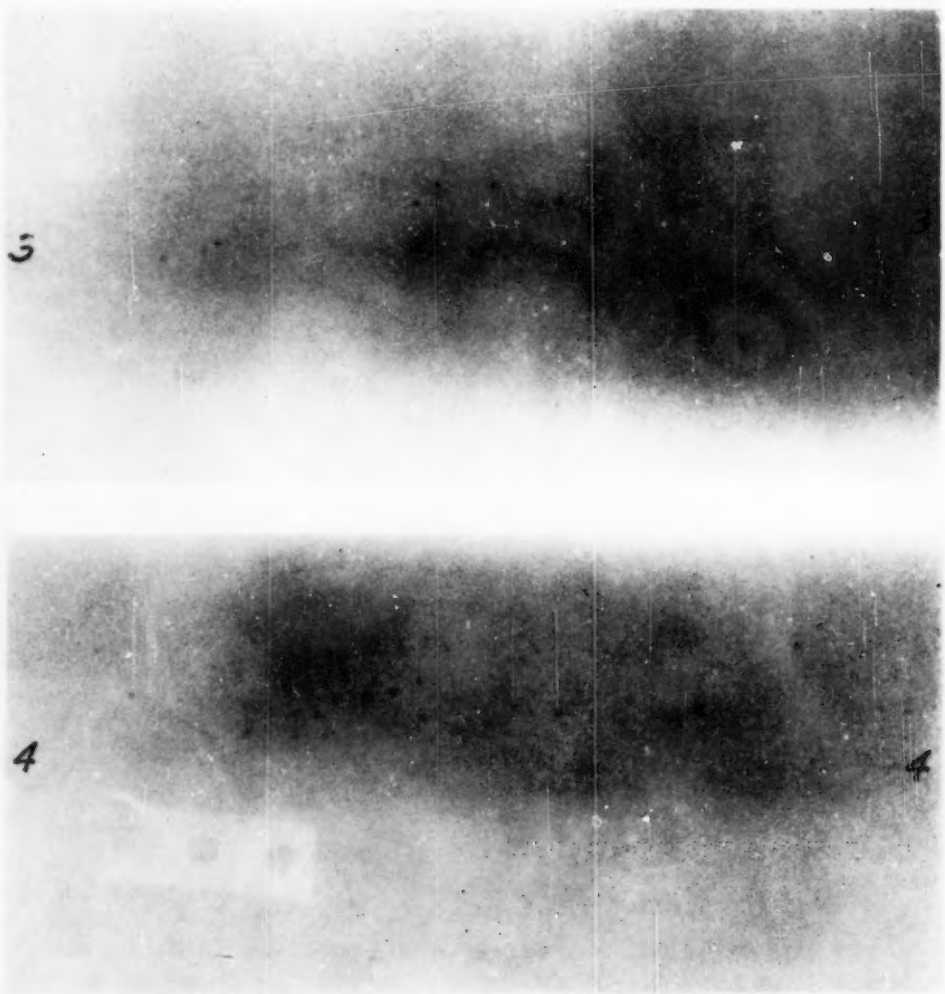


Fig. 2.—Radiographic Standards for Class A-1 Welds.
(3) Borderline Porosity—acceptable.
(4) Borderline Porosity—not acceptable.

Outside of the pressure vessel field, radiographic testing of welds is utilized by the Army and Navy and by commercial concerns manufacturing ordnance weldments. In these applications, not all of the welds are X-rayed. In some structures all of the important ones are and there is random examination of other welds. In other cases, a certain percentage of pieces is examined completely.

There are various commercial structures outside of Army and Navy weldments to which the method has been applied. Gamma rays have been used in cases where for various reasons X-rays could not be employed. The latter are preferred for the examination of welds because of their greater sensitiveness and because, for most shop applications, they save time.

While inspection is the emphasized feature, in the weld shop X-ray examination is carried out mainly by the producer and is used as much for development and control as for final inspection. The individual welder is qualified partly on the basis of radiographic tests. His production work is checked daily by X-ray pictures. This supervision gives close control, reduces final inspection to a formality, and practically eliminates large losses through final rejections.[7]

[7] The Welding Handbook issued in 1938 by the American Welding Society contains a chapter on Radiography that gives a fairly complete picture of the radiography of weldments.

It is interesting to note that according to opinion expressed in one of the 1938 surveys mentioned above, the producers and consumers alike are enthusiastically in favor of X-ray tests for weldments. It was brought out that to date there is no record of failure of a weld manufactured under X-ray control and stress relieved. This is a rather strong endorsement of X-ray control.

One interesting application (6) that really comes under the head of weld applications is the examination of composite gold plate where unfused regions between the 1/8-in. gold sheet and the base plate are detected before rolling the block to final thinness. One important company examines all of its brazed composite plates by X-ray.

INDUSTRIAL RADIOGRAPHIC COMMITTEES

Progress in the application of radiography to the problems of industry has been facilitated by various committees devoted to such interests. The A.S.T.M. was first to recognize the method and has had a subcommittee on X-ray Metallography since about 1925. Other groups are the Radiographic Committee of A.F.A., the Joint American Society of Mechanical Engineers - American Petroleum Institute Committee on Radiography of Welds, and the Subcommittee on Nondestructive Tests of the Welding Research Committee under the Engineering Foundation. During the past year, the A.S.T.M. has reorganized its work on radiography, formerly handled as a subcommittee on X-ray Metallography, and has set up a new standing committee on Radiography. This new body has a membership of about forty-five. It aims to be broadly representative of all radiographic interests. The membership includes important representation from each of the other radiographic committees. There are six subcommittees dealing with "Castings," "Welds," "Technical Research," "Correlated Abstracts," "Safety," and "Technical Programs," respectively. The first technical program sponsored by the committee was presented at the 1938 Annual Meeting of the A.S.T.M.

The casting subcommittee, under C. W. Briggs, has mapped out a comprehensive program involving extensive cooperative effort among the organizations represented. It contemplates pictorial definitions of defects, education of consumers to porosity conditions inherent to design, a study of possible economical applications of the method to foundry problems, and various other details leading eventually to a sane basis for the formulation of radiographic specifications for the manufacture of steel castings.

The welding subcommittee also has a program under way, the chief feature of which is the evaluation in terms of physical quantities of the defects seen in radiographic negatives.

The subcommittee on technical research, under the leadership of H. E. Seemann, has contributed already four worthwhile papers (7, 8, 9, 10). They are by individuals of the committee and do not represent cooperative effort.

One broad purpose of the activities of the research committee is to work for improvements in radiographic negatives. Eventually it is hoped that they will have the clarity and detail of good photographs. Such pictures can be produced now in some kinds of medical work and when examining thin metal sections. For the most part, however, industrial radiographs are very far from ideal. A first approach to the general problem is obviously a systematic study of the various factors that influence the quality of negatives. The four papers referred to were directed along this line. One considered conditions of image formation (9) with regard to different distances between source of radiation, specimen, and film. The other three were devoted to the problem of intensifying screens and to the study of secondary radiation. One of them (7), by the chairman of the subcommittee, H. E. Seemann, was written before the subcommittee was organized. It is included as a committee contribution because it is a preliminary study of the factors involved in intensification. A second report (10) on the screen problem is among the annual meeting papers. Others will no doubt follow. In the 1937 report (7), Seemann discussed the two factors involved in the intensifying action, direct electron action and fluorescent radiation. He has devised an ingenious method for evaluating the two effects and offers quantitative measurements of them. The radiation effect is shown to be due to the characteristic K radiation of lead. With the usual arrangement of front and back screens and double coated films, it is found that the electron effect accounts for 84 per cent of the intensifying action for the front screen and 75 per cent for the back screen.

A preliminary study of the effect of lead foil in reducing objectionably secondary radiation is also included in this paper. A further development of this feature forms the substance of another of the 1938 papers (8).

In the 1938 paper on intensifying screens (10), the relative efficiencies of calcium tungstate and lead foil screens are compared for gamma-ray radiography. Calcium tungstate screens were found to give shorter exposure times but the blackening of the film was not consistent with an inverse square law for the intensity of radiation from the gamma-ray source. Lead screens, though slower, gave more consistent results and better definition.

The problem of secondary radiation from the portion of the specimen adjacent to the film is probably the most important one up for solution today. It is particularly vexatious in the X-raying of metal specimens above 1½ in. thick. Secondary radiation is the re-radiation by the specimen due to its absorption of some of the primary radiation that proceeds from the X-ray tube. The optical density of the negative comes partly from the primary radiation, which alone is responsible for image formation, and partly from the secondary radiation which produces a general fog over the negative and obscures the images that may be present from the primary beam.

The solution of the secondary radiation problem is a present active consideration of the research subcommittee. Preliminary studies were reported in the 1937 paper (7) referred to above. In this paper it is pointed out that the secondary radiation is ordinarily of longer wave length than the primary and that differential absorption of primary and secondary radiations is possible. Quantitative measurements are given. In the 1938 paper (8) by the same author, the effects of secondary are discussed and a method of measuring this quantity is described. In the experimental results obtained, it was found that almost one-half of the secondary could be removed by filtering through lead foil. An almost linear increase in secondary with increase in thickness of material was found, and there was no appreciable variation of secondary with variation of potential on the X-ray tube for

a given specimen. These experiments were carried out with aluminum. It is rather probable that the results will be different for steel.

The joint A.S.M.E.-A.P.I. committee for the radiography of welds has been in existence some years. To it come radiographic questions that concern the A.S.M.E. and A.P.I. construction codes for welded pressure vessels. A report presented in June[8] concerned penetrameters and a test block. The penetrameter, hitherto prescribed in the code, is a piece of steel ½ in. wide and arranged in steps ½ in. long and of graded thicknesses so that the thickness of one step is 2 per cent of the thickness of the metal being radiographed. Each step contains a hole ⅜ in. in diameter drilled through the ½-in. square face. The device is placed alongside the weld being radiographed and its image appears in the negative. If the hole corresponding to the 2 per cent step shows, it is assumed that all cavities in the metal of equal or greater thickness dimensions are shown. It was supposed to be a sensitivity gage. In practice, it was discovered that cavities greater than 2 per cent sometimes did not show in the negatives although penetrameter holes corresponding to as low as ¾ or even ½ per cent could be shown. There was objection also because the regular gradation of steps with the equal spacing of holes led to optical illusion, so that the 2 per cent image was often seen when it really was not visible.[9]

In the above, an attempt has been made to sketch briefly, though incompletely, the development of radiographic testing in the United States and to present the trend of modern thought in this important field of nondestructive testing. Emphasis has been given to practical applications and to technological research of direct bearing on industrial usage. The authors desire to acknowledge the assistance of the General Alloys Co. of Boston in supplying the illustrations in Fig. 1, to the U. S. Navy Bureau of Engineering for permitting the use of unpublished data, to C. W. Briggs, H. E. Seemann, G. E. Doan, and to the A.P.I.-A.S.M.E. Radiographic Committee for use of unpublished data.

[8] Not published—A résumé will be presented as a report to Committee E-7 on Radiographic Testing of A.S.T.M. and will probably be available through that Society.

[9] Since the use of the penetrameter has been discussed fully in the paper by the author on "Radiography in Industry," ASTM BULLETIN, No. 94, October, 1938, pp. 12 and 13, readers are referred to this paper for complete details.

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(5) H. E. Seemann, "Miscellaneous Applications of Radiography and Fluoroscopy," Symposium on Radiography and X-ray Diffraction Methods, p. 92, published by the American Society for Testing Materials (1936). (Symposium available as separate publication.)

(6) W. J. Wrighton and Tracy C. Jarrett, "Radiography of Composite Gold Plate," *Metals and Alloys*, Vol. 8, No. 3, March, 1937, pp. 78-79.

(7) H. E. Seemann, "Some Physical and Radiographic Properties of Metallic Intensifying Screens," *Journal of Applied Physics*, Vol. 8, No. 12, December, 1937, pp. 836-845.

(8) H. E. Seemann, "Secondary Radiation in the Radiography of Aluminum, Steel, and Lead," *Proceedings*, Am. Soc. Testing Mats., Vol. 38, Part II, p. 284 (1938).

(9) Gilbert E. Doan and Shang-Shoa Young, "Gamma-Ray Radiography," *Ibid.*, p. 292.

(10) Charles W. Briggs and Roy A. Gezelius, "A Study of Intensifying Screens for Gamma-Ray Radiography," *Ibid.*, p. 303.

Inter-Society Color Council Meeting

THE Eighth Annual Meeting of the Inter-Society Color Council, of which A.S.T.M. is one of the member bodies, will be held in New York City on February 23 in the auditorium of the Electrical and Gas Association, 480 Lexington Ave. The meeting will be held during the week in which the Technical Association of the Pulp and Paper Industry and the Optical Society of America, two member bodies of the Council, hold meetings in New York City.

The morning meeting at 9:30 o'clock is the business session at which reports of committees and reports from chairmen of delegates of each member body will be presented. At the afternoon session beginning at 2 o'clock, there is a technical session on color tolerances with the following papers. This session is sponsored jointly by the Council and the American Psychological Association.

The Physics of Color Tolerances—Deane B. Judd, National Bureau of Standards.
The physicist evaluates color difference operationally in a standard coordinate system; perceptibility of color difference is relatively unimportant in tolerance consideration.

The Psychophysics of Tolerances—Edwin G. Boring, Harvard University.
The fundamental significance of the psychophysical methods and techniques in the evaluation of small sensory differences.

The Ratio Method in the Review of the Munsell Colors—Sidney M. Newhall, Johns Hopkins University.
A promising application in a different field of a psychological method which is being used in color tolerance determination.

Color Tolerances as Affected by Changes in Composition and Intensity of Illumination and Reflectance of Background—Harry Helson, Bryn Mawr College.
Typical data illustrating lawful relationships between the hue, saturation, and lightness of surface colors and principal conditions of viewing.

Representation of Color Tolerances on the Chromaticity Diagram—David L. MacAdam, Eastman Kodak Co.
The ICI coordinate system is recommended for color tolerance representations; use of a coordinate system based on just noticeable color difference data would be unjustified and misleading.

Specification of Color Tolerances at the National Bureau of Standards—Deane B. Judd, National Bureau of Standards.
Color tolerances have been applied by (1) specification of a mixture diagram, (2) use of a standard tolerance and sample, and (3) use of the "NBS unit of surface-color difference."

Industrial Color Tolerances—Isay Balinkin, Cambridge Tile Manufacturing Co., Cincinnati, Ohio.
Techniques and results in the establishment of color tolerances for particular products and purposes, and with special reference to ceramics. Control of color uniformity by determination of rates of color variation as a function of various physical or chemical factors.

There will be an exhibit of color tolerance problems in connection with the afternoon program.

The evening session at 8 o'clock is in the nature of a parade of color, the purpose being to illustrate the color interest of each of the groups who comprise the Council. Presentations are to be made in the popular manner. Tickets must be obtained for this evening session and as long as the supply lasts they will be furnished without charge on request to the secretary of the Council, Miss Dorothy Nickerson, Bureau of Agricultural Economics, Washington, D. C.

A New Paper Crush Tester

By Pierre Drewsen[1]

A NUMBER of committees in various societies are now at work formulating standard methods for testing corrugating and container board for stiffness. Until a standard method is developed and accepted by the various mills and box plants, each manufacturing unit will continue to use its own procedures.

A paper crush tester has been developed by the Hinde & Dauch Paper Co. to satisfy the need for a practical, sturdy, heavy-duty machine, suitable for 24-hr. per day service in paper mills, for controlling the quality of paper for corrugating and container liner. (See Fig. 1.) The instrument formerly used for this purpose was the Webb Paper and Box Tester, now no longer made. The Webb tester proved to be somewhat too fragile for the relatively heavier load requirements of modern container board. The capacity of the present tester is 350 lb. It is possible that this instrument may find a field of usefulness outside of the paperboard industry, for example, in any industry where the product is required to withstand a relatively low capacity compression. The maximum size sample which this machine will test is a rectangular parallelepiped $3\frac{1}{2}$ by $3\frac{1}{2}$ by $2\frac{3}{4}$ in. high.

The mechanism of this tester is free from any frictional factors which may cause an inaccuracy on the load-recording dial. The breaking load is transmitted directly to the sample and thence to a steel bar by means of a standard steel plate on which the sample rests. The bar deflects 0.001 in. for each pound of load, and when the sample breaks the bar tends to return to its original position, the breaking load being indicated on the load-recording dial. The mechanism is motor driven, and the construction is such that no lateral forces can come into play. For this reason, flat crush tests on corrugated paper without side slip have not only become possible but are now made as a matter of daily routine.

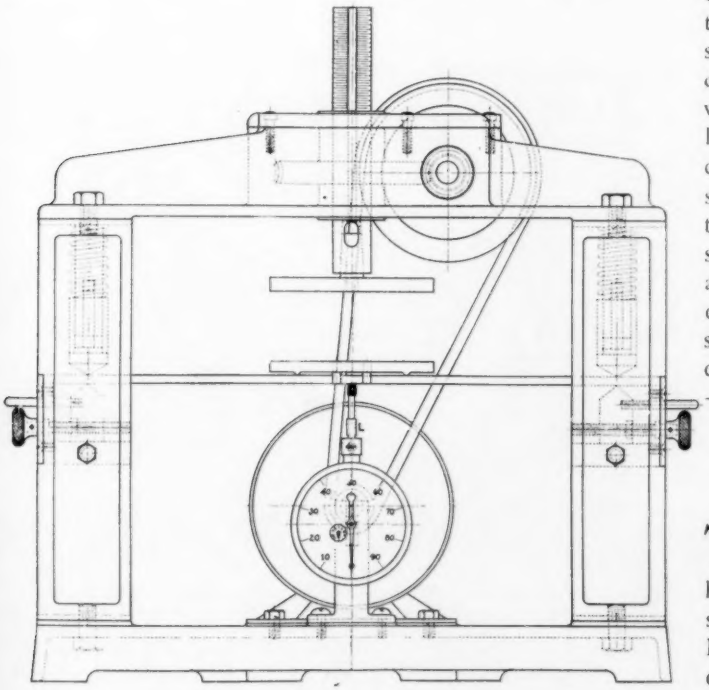

Fig. 1.

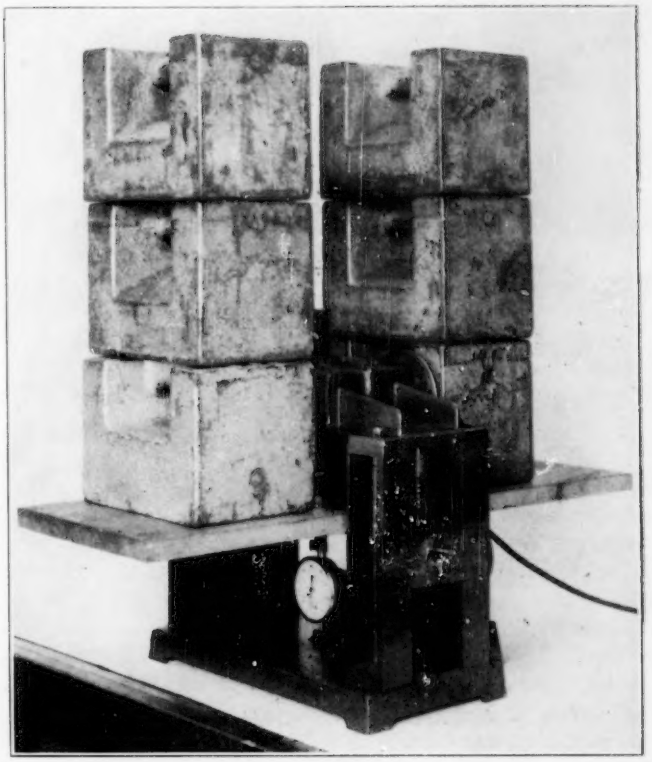

Fig. 2.

The machine can be checked for accuracy by using test weights as indicated in Fig. 2. If the dial records a load different from the test weights, the shoulders on which the bar rests are moved inward or outward until the reading is accurate.

For testing corrugating paper there are two general kinds of samples in use: first, small cylinders made by curving pieces of paper 2 to 6 in. long and $\frac{1}{2}$ in. wide, into a cylinder until their ends abut or overlap, and crushing them vertically on end while held in position in a metal template; secondly, rectangular or circular pieces of single-face or double-face corrugated board from 1 to 10 sq. in. in area which are crushed flat, the force being applied perpendicular to the board surface. The former requires a cutting board capable of trimming samples of absolute accuracy, and the second, a circular cutter, if this is the shape desired. Crush tests are usually made either on a bone-dry basis, or else on samples which have been conditioned to constant weight in an atmosphere of regulated humidity. The tests on flat paper cylinders give an index number which is proportional to stiffness. Results of flat crush tests on single or double-face corrugated board are expressed in pounds per square inch.

[1] Chemical Engineer, The Hinde & Dauch Paper Co., Sandusky, Ohio.

Trade Agreements Available in Booklet

THE complete official text and duty rates of the United Kingdom and Canadian Reciprocal Trade Agreements have been prepared in convenient booklet form in the pocket-size December issue of the "American Import & Export Bulletin." Copies can be obtained by sending $1.00 for each copy to the publishers—American Import & Export Bulletin, 420 Lexington Ave., New York, N. Y.

Discussion on Fatigue of Metals[1]

By R. K. Bernhard[2]

THE very valuable paper by R. P. Seelig on "Recent Developments in European Research on Fatigue of Metals" might be supplemented by some experiences the author had in carrying out similar tests in Europe.

These experiments refer to fatigue investigations with respect to the so-called "form factor" in welded connections.

Welded connections are usually more rigid than similar riveted connections; therefore, in most cases, they are more sensitive to alternating stresses. To overcome this distinct disadvantage of welded structures, the shape of the connections, or "form factor," has to be taken into account. In other words the welded connection has to be adapted for both butt welds and longitudinal welds to the typical character of each individual seam.

Two striking examples might be described, indicating the gradual development from the original imitation of the corresponding rivited connection to the welded connection, rearranged conforming to its characteristic weaknesses.

This development is demonstrated for a simple T- or I-beam in Fig. 1 (*a*) to (*e*). Two or three plates welded together in the conventional manner of a riveted connection

Fig. 1.—Development of Welded Cross Section (T- or I-beam)
Arrows indicate stress directions.

is a very poor solution of the problem. Keeping in mind the stress distribution, especially from a dynamic viewpoint, it is clearly to be seen in Fig. 1 (*a*) that the remaining notch between two adjacent plates forces the stresses to a sudden change in direction, hence causing the well known dangerous drop of the endurance limit. A certain improvement is shown in Fig. 1 (*b*). The seams are no longer in the extreme corner, where the stresses suddenly change their direction and hence form spots which are particularly dangerous for all types of welds. The advantage of grooved cover plates is that the groove prevents any buckling of the web, caused by heat development during the welding procedure. However, keeping the rolling process in mind, the complicated form of the cover plate is not very economical. Furthermore, the notch between two adjacent plates cannot be avoided. Figure 1 (*c*) indicates the next step in this development. Tapering the web facilitates X- or U-welds, hence avoiding any sudden change in stress direction, in other words decreasing the notch effect. However, the welds are not yet removed from the dangerous corner. Another form of cover plate is shown in Fig. 1 (*d*), thus removing the welds from the outside corner. A T-beam or an I-beam cut into halves indicates the next improvement (Fig. 1 (*e*)). Two distinct advantages are obvious: first, no special form of cover plate is required, and second, the welds are shifted nearer to the neutral axis of the beam, thus reducing substantially the stresses in the welds.

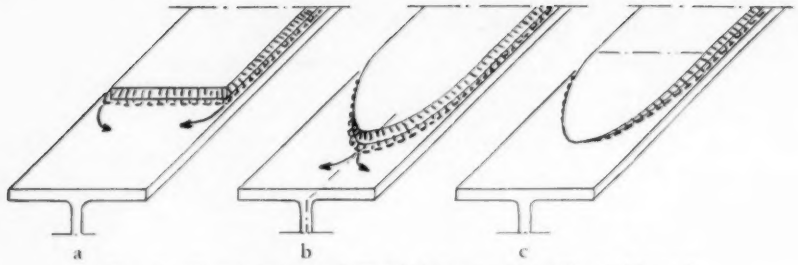

Fig. 2.—Development of Welded Coverplate (T- or I-beam)
Arrows indicate start of fatigue cracks.

A similar development is shown in Fig. 2 (*a*) to (*c*) for an I-beam with a second cover plate as reinforcement. Figure 2 (*a*) indicates a copy of the corresponding riveted connection. The abrupt change in cross-section at the end of the cover plate will cause typical fatigue failures under vibrating loads. Fatigue cracks will start at the outer corner of the second plate. Hence the next step in this development was an elliptic end of the second plate (Fig. 2 (*b*)). However, the fatigue cracks started from the rather pointed edge of the elliptic end of the cover plate. The heat development from the three adjacent welds, the seam of the cover plate combined with the two seams of the web underneath, caused a hardening effect at this particularly dangerous point (Fig. 3). Therefore, the wedge form of the cover plate as shown in Fig. 2 (*c*) improved the "form factor" considerably, thus avoiding the above mentioned disadvantages. The welds along the cover plates decrease with the second tapered plate simultaneously and are almost zero at the elliptic end.

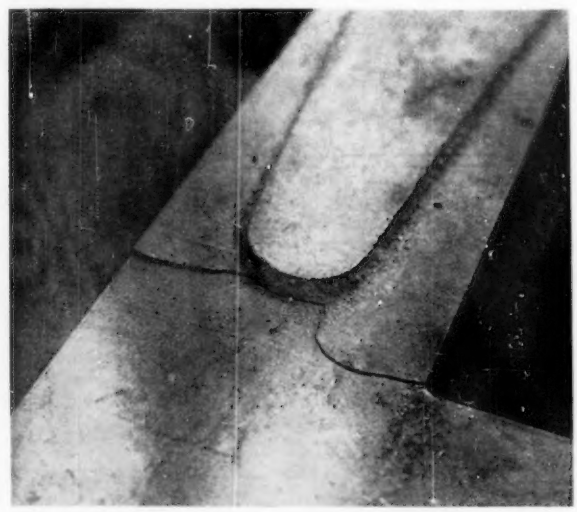

Fig. 3.—Determination of the "Form Factor" by Means of Induced Vibrations on Full-Size Welded I-beam

Typical fatigue cracks at end of cover plate due to sudden change in cross-section.

Improvement by tapering cover plate and simultaneously decreasing weld to dangerous point.

[1] ASTM BULLETIN, Nos. 94 and 95, October and December, 1938, pp. 23 and 15, respectively.

[2] Professor and Head of Department of Mechanics and Materials, The Pennsylvania State College, State College, Pa.

Practically no forces are transformed at this dangerous point. Therefore a gradual change of forces from the first to the second cover plate is guaranteed.

A similar adaptation to the welding method had to be developed with complete vertical joints of I-beams. The author had the opportunity to carry out some of the tests during the above mentioned development. These investigations for the most part have been made under the auspices of the German State Railroads. A considerable amount of the test work was performed with the method of "Induced Vibration"[3], either on full size girders or on smaller models (Figs. 3 and 4). The result of all these investigations was the development of the best "form factor" for each individual connection, either welded or riveted. The welded connections have been gradually improved to such an extent that they developed, if not a higher, at least the same endurance limit as the corresponding riveted connection.

[3] R. K. Bernhard, "Dynamic Tests by Means of Induced Vibrations," *Proceedings*, Am. Soc. Testing Mats., Vol. 37, Part II, p. 634 (1937).

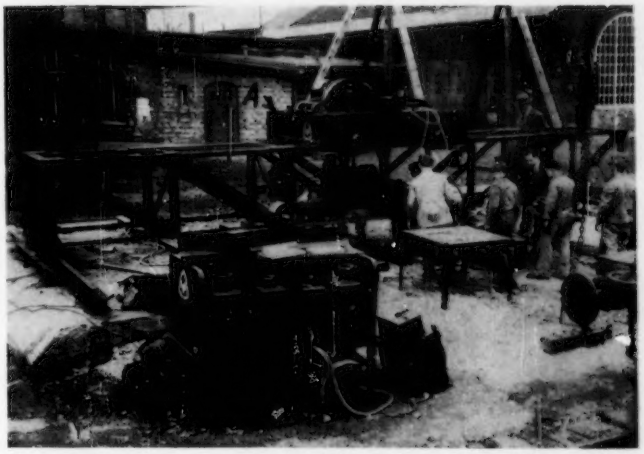

Fig. 4.—Determination of the "Form Factor" by Means of Induced Vibrations on Riveted Model Truss (Span 27 ft.)

A. Oscillator to induce vibrations, consisting of two eccentrically supported masses, revolving in opposite directions.

B. Rheostats to control amplitude and frequency of induced stresses, by changing rotational speed of driving motor.

Proceedings Nearing Completion

PRESSWORK on the *Proceedings* of the 1938 annual meeting is practically completed and the two extensive volumes will be placed in the mails in the very near future for distribution to each member of the Society. The 1938 *Proceedings* are issued in two parts, Part I giving committee reports and all new tentative standards approved this year, while Part II contains the technical papers presented at the annual meeting. This is the last volume of the *Proceedings* which will be issued in two parts since the new publication plan (to go into effect in 1939) involving a complete change in the Book of Standards (to be combined with the Book of Tentative Standards) in three parts, provides that in 1939 and thereafter the *Proceedings* will be issued in one book, the committee reports and technical papers appearing in the one publication. The practice of including in Part I of the *Proceedings* all new tentative standards of the current year will be discontinued since these will appear either in the Book of Standards or in the Supplements thereto.

Part I of the current *Proceedings* aggregates some 1402 pages. It includes the annual reports of some 53 standing, joint or sectional committees. Several of the reports include appended papers discussing phases of committee work and a number also give for information and comment, proposed standards.

A proposed method of testing cathode sleeves and cathode tubing is part of the Report of Committee B-4 on Electrical Alloys. The latest proposed method of test for autoclave expansion of portland cement is included in the Report of Committee C-1 on Cement—and Committee C-7 on Lime has specifications published for information covering quicklime for causticizing leached liquors in the soda-pulp process for the manufacture of paper; quicklime for use in the manufacture of paper pulp where the precipitated carbonate is employed as a pigment or filler; and method for determination of available lime in high-calcium quicklime and hydrated lime by the rapid sugar test. A proposed method of test for ignition quality of Diesel fuels and the latest Diesel-fuel-oil classification are a part of the report of Committee D-2.

This part of the *Proceedings* includes a number of items which were not preprinted in advance of presentation at the meeting, including the paper on "Methods of Testing Thermometers" by E. F. Mueller and R. M. Wilhelm which is appended to the Report of Committee E-1 on Methods of Testing.

The committee reports comprise 530 pages and the remaining 872 pages give all of the new or revised tentative specifications and tests acted upon in 1938; proposed revisions of standards are also given. From the standpoint of typography, it is of interest to note that for the first time the reports of the committees are set in the new double column format.

Part II of the *Proceedings*, comprising technical papers, includes the Marburg Lecture on "The Torsion Test" and the Symposium on Impact Testing with its nine extensive technical papers. Of the 33 other technical papers given in this volume, 13 relate to ferrous and non-ferrous materials; eight cover topics on cement, concrete, lime, ceramics and masonry materials; and twelve cover other fields such as rosin, transformer oil, greases, highway materials, boiler feedwaters, etc.

The 684 pages in Part II in double column format are equivalent to about 850 pages of the style used prior to 1937.

A number of the papers presented at the 1938 annual meeting were not preprinted and these of course are given in this part of the *Proceedings* or in various issues of the ASTM BULLETIN. Several of the annual meeting papers have been published in the BULLETIN. These are indexed in Part II so that members can refer to the respective numbers for them.

Group Orders for "Metals and Alloys"

THE magazine "Metals and Alloys" has recently reduced its subscription prices, establishing a two-year price, and has also offered to supply subscriptions at $1 per year, providing five or more are ordered at the same time. Those who wish to take advantage of this offer by forming a group of five or more can send their orders to Mr. John Zellner, Circulation Manager, Metals and Alloys, 330 West 42nd St., New York City. Further information can be obtained by writing the Circulation Manager.

ASTM BULLETIN

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No.96 January, 1939

Never Satisfied

ON an accompanying page is an excerpt from the Presidential Address of Henry Marion Howe presented in 1911. The excerpt and the address are worth reading. It is the misfortune of most who will read this article never to have known him—a review of some of his writings gives a pretty clear conception of his stature as a metallurgist and administrator, as a clear thinker, and especially his ability adequately to express himself in writing. His choice of words and the exact shades of meaning they convey mark this ability as outstanding.

The very next sentence following the excerpted material states "It is a part of true service as of true love that it is never satisfied with itself, but is always seeking to do more and better." Then follows discussion of two ways in which service of the Society and its members could be made more fruitful and at some length Doctor Howe stresses the importance of tests to determine service usefulness. He directs attention to the importance of an empirical method of solving our problems, but lays stress especially on the difficult but probably valuable way of making empirical methods more constructive.

In his paper on "Service Tests for Packings," in the December issue of the BULLETIN, F. C. Thorn points out that testing is not limited to tests for composition, strength and other items composing the bulk of acceptance specifications, but that the ultimate test for everything is service and that any kind of a test needs to correlate with service. An apt question might be "How much progress has been made along these lines from the time of Howe?"

Unquestionably, a good deal. A number of tests, more or less of a performance nature, have been developed. Accelerated tests are another approach. But the difficulties are great and in many fields a test to show the exact service rating of the material seems quite remote. Nevertheless, the work that has been done and is under way is significant. There is still much food for thought in Doctor Howe's statement that "However confident we may be that we shall one day have laboratory tests, the results of which shall be directly convertible into the power to perform each of the several distinct duties, the difficulties in the way are so great, the distance we have traveled is so slight compared with that which lies beyond, that for a very long time we must rely to a great extent on empirical methods, remaining in the dark as to why it is that such or such specific test is needed and suffices."

But the engineer of materials, like the members of many other professions, is never satisfied, and this is part of true service.

Come One, Come All

THE Regional Meeting in Columbus to be held during A.S.T.M. Committee Week, March 6 to 10, is described in this BULLETIN. It is significant from several angles. From each regional meeting there has come technical information and data of much value. The publications which have usually resulted giving in convenient form the papers and discussion comprising the technical symposium have made this information available conveniently to all engineers interested.

Each regional meeting enables members in the industrial area where held an opportunity to participate. Many members have never been able to attend our annual meetings or other gatherings of the Society. This is one of the underlying purposes in arranging for such regional meetings and the Executive Committee in selecting a location keeps this point definitely in mind. This first meeting in Columbus, therefore, is an opportunity for a large number of members in the Ohio section to participate in an important meeting of their Society.

The original purpose in establishing Committee Week still holds, namely, providing an opportunity for individuals serving on more than one committee to conserve time and expense in a concentrated period of meetings. The week this year will be extremely active because all specifications are under review and, too, the volume of new work is heavy. Detailed studies are made to schedule the large number of meetings so that membership conflicts will be kept to a minimum. Some necessarily result where members are affiliated with a large number of committees, but by and large the week does serve its original purpose in an efficient manner.

While committee meetings are not open to the general public, members of the Society and other technical visitors are usually welcome. Those having a definite interest in attending a given meeting should contact the appropriate committee officers.

Details

A SHORT article in the December BULLETIN illustrated the new typographic style to be used in publishing standards, which is to be used in the new combined Book of Standards and Tentative Standards (publication date—November, 1939). This mentioned the detailed studies under way in achieving desirable editorial conformity in sentences and clauses covering essentially the same tests or properties in specifications in similar fields. The ultimate decisions are made by the standing committees themselves, most of whom have editorial groups, although in many cases the chairmen and subcommittee chairmen are the court on editorial matters. This extensive work impresses on us more and more the im-

portance of little things in the testing of materials—the subject of the presidential address some years ago and a short editorial in a former BULLETIN.

Quite a few inconsistencies have been brought to light and the final results of all this work are bound to be most fruitful to the user of the specifications and tests. This, too, may be considered an essence of service—not satisfied with existing situations, but seeking to improve the standard.

Let it not be said that this is "comma chasing." Much of this phase of the committee's work goes on unheralded and unsung. It is without question one of the important parts of preparation of specifications and tests.

A word of appreciation to the large number of men who have cooperated in this work and a "thank-you" in advance to many others who will be asked to help.

WHAT THEN IS OUR GREAT SERVICE, and how may we increase its value to our fellows? Ours is a work, if I mistake not, akin in a way to lubrication and in another way to piloting. We reduce the friction of our fellow's work and thereby we make it more efficient, more fruitful; we guide it, and thereby again make it more fruitful. By improving methods of testing we teach the manufacturer how he may most wisely test his product so as to know most readily and most surely that he is truly serving the buyer and through the buyer the great world which the buyer in turn serves; that his product really has the qualities which fit it for the service of the user. By this same step we enable the user to learn most readily and surely that his purchase really has the qualities which will enable him, by its use, to serve the public efficiently.

By setting up standard specifications to serve as standards of reasonableness, of what is just and proper, of what safeguards the buyer with the least hardship to the maker, we do two things.

First, we teach both parties what specific qualities each given product needs in order that it may best fit its use. We help the maker to give surely and the buyer to require firmly those specific qualities which will fit the product for its future service, so that that product may the better serve that fraction of mankind which its final users form.

Second, we help maker and buyer to agree. We find them, human fashion, each glaring fixedly at that side of the gold and silver shield which faces him, one firm in his belief that it is gold, the other swearing that it is silver. Having looked the shield all over, we induce each to take a peep around the corner and see its other side. We do our share of the great work of the twentieth century, the substitution of cooperation for combat. By helping both parties to see both sides of the question, to see the true needs of the public which, in the end, we all serve, we help both parties to approach and at last to attain the attitude of cooperation in striving toward their common true interest, to serve that public the best.

HENRY M. HOWE.

Annual Address by the President, 1911.

Membership Growing Slowly

STATISTICS on the membership picture for 1938, while not impressive, are perhaps encouraging considering the below-par conditions which of course affect the growth of the Society. The year as a whole was closely comparable to 1935. The new members totalled 310, and deducting losses by death and resignation, there was a net growth of 80, bringing the membership on December 31, 1938, to 4160. The number of new members was considerably less than in the two previous years. A large number of members of the Society have cooperated in bringing the advantages of membership to the attention of many individuals and companies. This is an important phase of work in which *every* member can participate. Only through the combined efforts of a large number of those now active in the Society can the increased growth that is necessary in carrying forward undiminished so many important activities in the materials field be achieved.

There are a large number of engineers, and companies with whom they are affiliated, concerned with fields of work in which the Society carries forward standardization and research activities. While in many cases these organizations may be following the Society activities in a general way and are acquainted with its publications, there are nevertheless numerous membership prospects in practically every industry.

140-Page Index to Standards—Extra Copies Available on Request

IN the near future each member of the Society will receive a copy of the Index to A.S.T.M. Standards and Tentative Standards, as of January 1, 1939. As the number of specifications and tests issued by the Society increases, this Index becomes of more value. It gives under appropriate key words the titles of all A.S.T.M. standards and tentative standards, together with page references to the current Society publications in which they may be found. Each standard is carefully cross-indexed under the principal subjects it covers.

The Index is of particular value for two reasons: First, it enables a particular item to be located quickly; second, it provides a quick reference for anyone who wishes to determine whether or not there is an A.S.T.M. specification, test, definition, etc., on a particular subject or material.

In addition to a detailed subject listing, there is given a complete listing of A.S.T.M. designations in numeric sequence. This latter is of assistance in determining the subject matter and publication references of a standard when only the designation is known. The Index also includes a list of committees and officers of the Society and information on various publications.

No charge is made for copies of this annual publication. A number of members have standing requests for extra copies, using these for distribution to their associates and in other ways. Any member of the Society who would find it of service to have extra copies of this widely-used publication can obtain them by writing to the Society's Headquarters.

It is expected the Index will assume an even more important place in the publication set-up when the new plan of publishing the standards and tentative standards goes into effect next November, and plans are being studied by which the Index can be issued promptly after the three parts of the Book of Standards appear.

Schedule of Meetings

Date	Committee	Place
January 23, 24	Executive Commiteee	Philadelphia, Pa.
January 25, 26	A-1 on Steel	Philadelphia, Pa.
February 27	E-6 on Papers and Publications	Philadelphia, Pa.
March 1-3	D-13 on Textile Materials	Providence, R. I.
March 14	D-7 on Timber	Chicago, Ill.
March 6-10	Committee Week	Columbus, Ohio
March 8	Regional Meeting	Columbus, Ohio
June 26-30	42nd Annual Meeting and 5th Exhibit	Atlantic City, N. J.

Last Call for Annual Meeting Papers

At its meeting in Philadelphia late in February, Committee E-6 on Papers and Publications will give consideration to the papers which have been offered for presentation at the 1939 annual meeting to be held at Chalfonte-Haddon Hall, Atlantic City, June 26 to 30. A number of offers have already been received. All members and others who wish to present papers should send their offers to Society Headquarters not later than February 15 – blanks to be used in transmitting the necessary information can be obtained from the Society office.

SOCIETY APPOINTMENTS

Announcement is made of the following Society appointments:

N. L. Mochel, Westinghouse Electric & Manufacturing Co., Chairman of Committee A-1 on Steel, appointed by the American Standards Association as American representative on I.S.A. Committee No. 17 on Iron and Steel.

J. R. Townsend, Bell Telephone Laboratories, Inc., as a member of Committee E-10 on Standards, replacing J. B. Young, deceased.

H. H. Morgan, Manager, Rail and Fastenings Dept., Robert W. Hunt Co., reappointed as A.S.T.M. representative on the Mechanical Standards Committee of the A.S.A.

G. E. Hopkins, Technical Director, Bigelow-Sanford Carpet Co., Inc., appointed as American representative through whom communications with the Federal Lainiere Internationale, France, should clear.

W. J. Krefeld, Director, Engineering Materials Laboratory, Columbia University, representative on A.S.A. Sectional Committee on Building Code Requirements for Reinforced Gypsum Concrete.

L. V. Foster, Optical Engineer, Bausch & Lomb Optical Co., as representative, and H. E. Seemann, Physicist, Eastman Kodak Research Laboratories, Eastman Kodak Co., as alternate on A.S.A. Sectional Committee on Standardization in the Field of Photography.

L. F. Rader, Associate Professor of Civil Engineering, Polytechnic Institute of Brooklyn, represented the Society at the installation of Doctor Burdell as Director of Cooper Union, on November 3.

Conference on Instrumentation in Process Industries

Plans have been formulated for a conference on Instrumentation in the Process Industries, sponsored by the Chemical Engineering Department of the Carnegie Institute of Technology, Pittsburgh, Pennsylvania, on March 2-3, 1939. The purpose of the conference is to bring about a better knowledge of the advance made in measurement and control in the process industries. An exhibit will be held in conjunction with the conference. Dr. C. C. Monrad of the Department of Chemical Engineering is in charge of the arrangements.

Far-Distant Members

Editor's Note.—From time to time there have been published in the Bulletin biographical material and photographs of members of the Society who are located at far-distant points. The following article is based on material furnished on request by one of our members in Western Australia. Other articles in the Bulletin have described briefly the Forest Research Institute at Dehra Dun, India, and the Testing Laboratory at Bandoeng, Java, D.E.I.

J. M. Limb, Chief Chemist, Western Australian Government Railways, Midland Junction, Western Australia, has been a member of the Society since 1918. His appointment as Chief Chemist of the Western Australian Government Railways in 1901 was one of the first of its kind in Australia.

J. M. Limb

Prior to his work with the railways, Mr. Limb was an instructor in assaying and metallurgy at the School of Mines in Gawler, South Australia.

From its beginnings in Australia, Mr. Limb has been closely associated with the standardization of materials and methods of testing. In 1921, he was a member of the Australian Railways Committees appointed to prepare standards in connection with paints and varnish materials and practice, lubricants and methods of testing, and methods of water analysis.

The Standards Association of Australia was founded in 1922. Since 1924, Mr. Limb has represented the Railways as a member of the Sectional Committee for Paint and Allied Materials; and in 1925 was appointed chairman of the state sub-advisory committee for paints and allied materials. Later, he was appointed as a corresponding member for the standardization of lubricants and methods of testing, and for the sampling and testing of coals. He has also contributed to the Association's publication reviewing the coal resources of Australia.

Mr. Limb is one of a select body in being a Fellow of the Australian Chemical Institute; and in 1938 he was appointed by the Institute as one of its representatives on the newly-formed Chemical Industries Committee of the Standards Association of Australia. He is a foundation member of the Australian Chemical Institute and a past-president of its Western Australian branch, besides having served for many years as Honorary Treasurer and committee member.

During his long connection with the chemical profession in Australia, Mr. Limb has earned the high regard and esteem of his associates. His opinions and advice have frequently been sought by outside bodies, particularly in connection with lubricants and water treatment; and he has been instrumental in establishing water treatment plants in several important industrial units in Western Australia.

Several Publications Issued

SEVERAL special technical publications have been issued during the past few weeks. All of these were listed on the special Member's Order Blank sent out in September. With the exception of the "Index to the Literature on Spectrochemical Analysis" just coming off the press, and the compilation of standards on electrical insulating materials, to be published shortly, shipment has been made on all orders.

Three of the publications are special compilations of standards. Two are new editions of volumes issued in previous years, namely, the compilation of "A.S.T.M. Standards on Electrical Insulating Materials" and of "A.S.T.M. Standards on Cement." The former includes all of the 40 standard and tentative specifications and tests issued by the Society largely through the work of its Committee D-9 on Electrical Insulating Materials and covers the various materials and products in this field. In addition to the latest report of Committee D-9 there are included detailed statements concerning the significance of various tests as follows: Dielectric Strength Test, Resistivity Test, Power Factor Test, Impact Test, and Tensile Strength Test.

Since quite a number of changes were made in 1938 in specifications for cement, it was deemed desirable to issue a new edition of this publication, which was first printed as a special compilation in 1937. It gives all of the Society's specifications and methods of testing cement and includes the Manual of Cement Testing.

The third publication is one issued for the first time this year, "A.S.T.M. Specifications for Pipe and Piping Materials for High-Temperature and High-Pressure Services." This makes available in convenient form 18 specifications covering carbon-steel and alloy-steel pipe and tubing, castings, forgings and bolting. These standards have been developed through the work of Committee A-1 on Steel. There has been considerable interest on the part of technologists concerned with central power plants and related problems in this compilation and it is believed the publication will be of definite service to other technologists. The 135-page compilation has been issued in special ring binding with heavy paperboard covers, at $1.00 per copy to members; $1.25 to non-members.

The Symposium on Impact Testing held as the technical feature of the 1938 Regional Meeting has been reprinted from the *Proceedings* in the form of a 170-page book. This includes nine extensive technical papers covering present fields of commercial use of the impact test and giving detailed discussion of the basic theory of the impact test.

The fifth publication which is nearing completion is the "Index to the Literature on Spectrochemical Analysis" prepared by W. F. Meggers, Chief, Spectroscopy Section, and B. F. Scribner, National Bureau of Standards. This is the first general comprehensive index to spectrochemical literature that has appeared and is therefore of great significance to those in this field. It covers the years 1920 to 1937 inclusive and has over 930 entries, notwithstanding the fact that it is restricted to bibliography on chemical analyses by means of atomic emission spectra. Copies of this publication, heavy paper cover, can be obtained by members who have not previously ordered a copy, for 75 cents. The list price is $1.00 per copy.

Calendar of Society Meetings

(Arranged in Chronological Order)

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS—45th Annual Meeting, William Penn Hotel, January 23-26, Pittsburgh, Pa.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Winter Convention, January 23-27, New York City.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS—Annual Meeting, February 13-16, New York City.

ASSOCIATION OF HIGHWAY OFFICIALS OF NORTH ATLANTIC STATES—Annual Meeting, Hotel Pennsylvania, February 15-17, New York City.

ENGINEERING INSTITUTE OF CANADA—Annual General and Professional Meeting, Chateau Laurier, February 20-22, Ottawa, Canada.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Spring Meeting, February 23-25, New Orleans, La.

AMERICAN CONCRETE INSTITUTE—35th Annual Convention, March 1-3, New York City.

American Society for Testing Materials—Committee Week and Regional Meeting, March 6-10, Columbus, Ohio; Annual Meeting, June 26-30, Atlantic City, N. J.

AMERICAN ROAD BUILDERS' ASSOCIATION—Annual Convention and Show, Civic Auditorium, March 7-10, San Francisco, Calif.

AMERICAN RAILWAY ENGINEERING ASSOCIATION—Annual Convention, Palmer House, March 14-16, Chicago, Ill.

AMERICAN CERAMIC SOCIETY—41st Annual Meeting, Hotel Stevens, April 16-22, Chicago, Ill.

AMERICAN WATER WORKS ASSOCIATION—Annual Convention, June 11-15, Atlantic City, N. J.

Reports on Building Materials and Structures

MENTION has been made of the series of Reports on Building Materials and Structures being prepared by the National Bureau of Standards in Washington. These reports cover results of laboratory tests and other investigations and contain technical information on the engineering properties of building materials used in housing construction. Several of the reports have already been issued and quite a number of others are in course of preparation. The following list gives information on the items:

BMS1	Research on Building Materials and Structures for Use in Low-Cost Housing	10¢
BMS2	Methods of Determining the Structural Properties of Low-Cost House Constructions	10¢
BMS3	Suitability of Fiber Insulating Lath as a Plaster Base	10¢
BMS4	Accelerated Aging of Fiber Building Boards	10¢
BMS5	Structural Properties of Six Masonry Wall Constructions	15¢
BMS6	Survey of Roofing Materials in the Southeastern States	15¢
BMS7	Water Permeability of Masonry Walls	10¢
BMS8	Method of Investigation of Surface Treatment for Corrosion Protection of Steel	10¢
BMS9	Structural Properties of The Insulated Steel Construction Company's "Frameless-Steel" Constructions for Low-Cost Houses; Wall AH, Partition AI, Floor AJ, and Roof AK	
BMS10	Structural Properties of one of the H. H. Robertson Company's "Keystone Beam Steel Floor" Constructions	
BMS11	Structural Properties of the Curren Fabrihome Corporation's "Fabrihome" Constructions for Walls and Partitions	
BMS12	Structural Properties of "Steelox" Constructions for Walls, Partitions, Floors, and Roofs Manufactured by Steel Buildings, Inc.	

Those who are interested in these materials can have their names placed on a special mailing list to receive notices of new reports. This request should be addressed to the Superintendent of Documents, Washington, D. C. All orders and remittances for the reports should also be sent to the Superintendent of Documents.

PERSONALS

* * * News items concerning the activities of our members will be welcomed for inclusion in this column.

G. A. BOUVIER is now Director of Manufacturing Development, General Cable Corp., Perth Amboy, N. J.

H. F. HEDDERICH, formerly Superintendent of Physical Laboratory, State Highway Commission of Indiana, Indianapolis, Ind., is now Indianapolis Manager, Pittsburgh Testing Laboratory, Indianapolis, Ind.

H. D. MATTHEWS is Consultant on Thermostatic Bimetal, Minneapolis-Honeywell Regulator Co., Minneapolis, Minn. He was Director of Engineering, General Plate Co., Attleboro, Mass.

F. E. RUFERT, who was Chief Chemist, Anaconda Wire & Cable Co., Pawtucket, R. I., is now Chemist, Monsanto Chemical Co., Akron, Ohio.

IRVING HOCHSTADTER, Chemical Engineer and President, Stillman & Van Siclen, Inc., New York City, and Hochstadter Laboratories, Inc., New York City, was recently elected by the Board of Directors of the New York State Society of Professional Engineers as the National Director to represent New York State in the National Society of Professional Engineers.

A. V. DE FOREST, Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass., will receive the Sylvanus Albert Reed award for 1938 to be made on January 27. This annual reward for contributions to aeronautical engineering, by the Institute of Aeronautical Sciences, is in recognition of Professor de Forest's work on testing metals by magnetic analysis.

At the recent election of officers of the Engineering Foundation, F. M. FARMER, Vice-President and Chief Engineer, Electrical Testing Laboratories, New York City, was reelected chairman; G. B. WATERHOUSE, Professor of Metallurgy, Massachusetts Institute of Technology, chairman of the Iron Alloys Committee and COMFORT A. ADAMS, Professor of Engineering, Emeritus, Harvard University, Cambridge, Mass., and Consulting Engineer, Edward G. Budd Mfg. Co., chairman, Welding Research Committee. Mr. Farmer heads the executive committee and will represent the Foundation on the executive committee of the National Research Council.

L. R. FERGUSON, Vice-President, Lone Star Cement Co., Dallas, Tex., was recently elected president of the Texas Section of the American Society of Civil Engineers.

L. S. MOISSEIFF, Consulting Engineer, New York City, will be awarded the James Laurie Prize for his paper "Evolution of High-Strength Steels Used in Structural Engineering," at the annual meeting of the American Society of Civil Engineers to be held in New York City, Jan. 18 to 20.

Folders and Literature Received

PROCTOR & SCHWARTZ, INC., Seventh St. and Tabor Rd., Philadelphia, Pa. Proctor Laboratory Dryer, Bulletin No. 278. A four-page folder describing the new electrically-heated Proctor Dryer for laboratory use.

TINIUS OLSEN TESTING MACHINE CO., 500 North 12th St., Philadelphia, Pa. Ductility Testing Machines for Sheet Metal and Wire, Bulletin No. 15. A 15-page folder illustrating and describing the latest developments in ductility testing equipment, including the hand-operated machines as well as the more elaborate automatic clamping type, motor-driven ductility machines. A number of new machines are described in this book.

GEORGE SCHERR CO., INC., 128 Lafayette St., New York City. The "Compar" combined indicating micrometer and comparator—a three-page pamphlet describing this new micrometer with important new features.

THE EMIL GREINER CO., 55 Vandam St., New York City. An extensive new catalogue covering "Laboratory Apparatus and Chemicals." Issued in classified sectional form, with heavy board covers. There are some 22 sections comprising from 6 to 107 pages each. Main listings include petroleum, bituminous, gas apparatus, electrical equipment, centrifuges, porcelain and refractories, rubber goods, thermometers and hydrometers, pH apparatus, cement and soils and others. One entire section covers latest petroleum tables and formulae. References to publications and authors, a comprehensive outline of scope and method, amplify descriptions of the instruments and apparatus wherever desirable. A detailed subject index is included.

NEW MEMBERS TO JANUARY 2, 1939

The following 24 members were elected from November 22 to January 2, making the total membership 4181:

Company Members (6)

CAMPBELL, WYANT & CANNON FOUNDRY CO., L. B. Thomas, Head, Metallurgical Dept., Muskegon Heights, Mich.

DELAWARE TESTING LABORATORIES, INC., F. S. Pritchett, President, 321 Delaware Ave., Wilmington, Del.

GENERAL DYESTUFF CORP., H. W. Martin, Secretary, 435 Hudson St., New York City.

LUFKIN FOUNDRY AND MACHINE CO., R. E. Schuller, Chief Engineer, Lufkin, Tex.

OWENS-CORNING FIBERGLAS CORP., Jack H. Waggoner, Product Control Supervisor, Case Ave., Newark, Ohio.

WASHBURN WIRE CO., INC., R. S. Thompson, Metallurgist, 118th St. and Harlem River, New York City.

Individual and Other Members (16)

BECK, J. E., Metallurgist, Pittsburgh Works, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

BOETCHER, H. N., Assistant to Superintendent, Power Production Stations, Consolidated Gas Electric Light and Power Co. of Baltimore, Baltimore, Md.

BRANDT, MILLARD, Chemist, Atlas Powder Co., Experimental Laboratory, Tamaqua, Pa.

CAMPBELL COUNTY, R. L. Streeter, County Engineer, Gillette, Wyo.

CONSUMERS TECHNICAL INST., INC., D. H. Palmer, Executive Director, 55 Vandam St., New York City.

FINKBEINER, C. S., Partner, Champe, Finkbeiner and Associates, 725 Nicholas Building, Toledo, Ohio.

HOCHSCHWENDER, K., President, Chemnyco, Inc., 521 Fifth Ave., New York City.

LEAHY, J. A., Assistant Manager of Sales, Joseph T. Ryerson and Son, Inc., Chicago, Ill. For mail: 805 Wesley Ave., Oak Park, Ill.

LEDERER, JACKSON, Textile Technician, Herbert Manufacturing Co., New York City. For mail: 83-15 Lefferts Boulevard, Kew Gardens, Long Island, N. Y.

MILNE, W. G., Manager, N. Slater Co., Hamilton, Ont., Canada.

NELSON, L. M., Superintendent, City Electric Dept., 310 N. Broadway, Rochester, Minn.

O'DEA, D. R., Metallurgist, Australian Glass Manufacturers Co., Ltd., Dowling St., Waterloo, N. S. W., Australia. For mail: 123 Perouse Road, Randwick, N. S. W., Australia.

PEARSALL, D. E., Industrial Fellow, Mellon Institute of Industrial Research, Pittsburgh, Pa.

WAGNER, RICHARD, Student, Spring Garden Inst., Philadelphia, Pa. For mail: 7326 Dicks Ave., Philadelphia, Pa.

WILSON, WRIGHT, Chrysler Corp., Detroit, Mich. For mail: 6623 Appoline, Dearborn, Mich.

WINSMORE, K. B., Civil Engineer, Standard Oil Co. of Venezuela, Caripito, Venezuela.

Junior Members (2)

HEFT, G. A., Principal Designing Engineer, Union Station Project, Fourth Floor, City Hall Annex, New Orleans, La.

PENCE, J. O., Instructor, Chemical Engineering, Ohio State University, Columbus, Ohio. For mail: 21 E. Woodruff Ave., Columbus, Ohio.

NECROLOGY

We announce with regret the death of three members:

C. S. KOCH, President, Fort Pitt Steel Casting Co., McKeesport, Pa. Member since 1936.

PORTER W. SHIMER, President, Shimer Chemical Co., Easton, Pa. Member since 1899.

CARL R. WOHRMAN, The H. A. Wilson Co., Newark, N. J. Dr. Wohrman was a member of Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys and its Subcommittee VII on Thermostatic Metals.

Address Wanted

Anyone knowing the present address of R. C. Rich, whose last known address is 2505 Blodgett street, Houston, Tex., is asked to notify the Secretary-Treasurer.

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Radiography in Industry. H. H. Lester. No. 94, October, 1938, p. 5.
Recent Developments in European Research on Fatigue of Metals. Richard P. Seelig. No. 94, October, 1938, p. 23; No. 95, December, 1938, p. 15. Discussion, No. 95, December, 1938, p. 22.
Service Tests for Packings. F. C. Thorn. No. 95, December, 1938, p. 29.
Testing of Zinc (Hot Galvanized) Coatings on Hardware. L. W. Hopkins. No. 92, May, 1938, p. 7.
Testing Work in Indiana Highway Project. W. K. Hatt. No. 93, August, 1938, p. 30.
Tests for the Physical Properties of Textile Fabrics. Ethel L. Phelps. No. 90, January, 1938, p. 11.
Textiles.
Consumer Testing of Finished Textiles. Nannene Gowdy. No. 92, May, 1938, p. 9.
Crease Resistant Textile Finishes as Consumers View Them. Ephraim Freedman. No. 92, May, 1938, p. 13.
A Method for Measuring the Fluidity of Dispersions of Cellulose in Cuprammonium Solution. R. T. Mease. No. 93, August, 1938, p. 21.
Permanent Textile Finishes—The Manufacturer's Standpoint. K. H. Barnard. No. 92, May, 1938, p. 14.
Progress in Wool Standardization. G. E. Hopkins. No. 93, August, 1938, p. 12.
Tests for the Physical Properties of Textile Fabrics. Ethel L. Phelps. No. 90, January, 1938, p. 11.

Viscosity.
A Method for Measuring the Fluidity of Dispersions of Cellulose in Cuprammonium Solution. R. T. Mease. No. 93, August, 1938, p. 21.

Water.
Report of the Joint Research Committee on Boiler Feedwater Studies. No. 93, August, 1938, p. 32.
Velocity of Settlement of Soil Particles in Water. T. H. Evans. No. 91, March, 1938, p. 13.
Weld Tests.
Radiography in Industry. H. H. Lester. No. 94, October, 1938, p. 5.
Recent Developments in European Research on Fatigue of Metals. Richard P. Seelig. No. 95, December, 1938, p. 15. Discussion, p. 22.
Wool.
Progress in Wool Standardization. G. E. Hopkins. No. 93, August, 1938, p. 12.

X-ray.
Radiography in Industry. H. H. Lester. No. 94, October, 1938, p. 5.
Some Pros and Cons of Radiography. G. C. McCormick. No. 95, December, 1938, p. 25.

"Sampling and Analysis of Steels"

A NEW volume on "Sampling and Analysis of Carbon and Alloy Steels" has just been issued by the Reinhold Publishing Corp., 330 W. Forty-second St., New York City, giving methods of the chemists of the subsidiary companies of the United States Steel Corp.

The volume gives for the most part methods which are actually and frequently used by the committee in charge of the publication, but includes also procedures which are infrequently required by some laboratories. On the committee developing the book, there are many of the chemists and chief chemists of the steel companies in the corporation.

Following the section on sampling, a discussion of qualitative and quick tests for identifying various types of steel is given. Then follows details on methods of analysis and chemical separations, determination of manganese, phosphorus, sulfur, silicon, and copper and many other elements including arsenic, tin, selenium, boron, etc. In the appendix there is material on the determination of sulfur or carbon and sulfur by combustion in oxygen, discussion of methods for oxygen, and pH ranges and color charts of various organic chemical indicators.

Copies of this 350-page publication in cloth binding can be obtained from the publishers at $4.50 per copy.

1939 A.S.T.M. Regional Meeting, Columbus, Ohio, March 8, 1939
Deshler-Wallick Hotel

Abstracts of Papers

Symposium on Thermal Insulating Materials

Editor's Note.—There are published below, to stimulate discussion, abstracts of the four technical papers comprising the Symposium on Thermal Insulating Materials to be held at the 1939 A.S.T.M. Regional Meeting in Columbus, Ohio, on March 8. (See page 1 for details of meeting.) Written discussion may be transmitted to the Secretary-Treasurer, A.S.T.M., 260 S. Broad St., Philadelphia, for presentation at the meeting.

ABSTRACT OF PAPER ON

Factors Influencing the Thermal Conductivity of Non-Metallic Materials[1]

By J. B. Austin[2]

THE rather confusing lack of agreement among the values given in the literature for the thermal conductivity of many non-metallic materials arises largely from two causes. First, there is as yet neither a universally accepted standard method of measurement against which other methods can be checked, nor a standard sample with which a given apparatus can be calibrated. Second, there has been almost invariably an inadequate, or occasionally even improper, characterization of the sample tested; for example, it is not unusual to find a refractory classified only by its chemical composition or to see a sample described as a fireclay brick or a silica coke-oven liner, with no mention of other factors such as porosity which, as far as thermal conductivity is concerned, may be of much greater significance than the composition.

Since steps toward the removal of the first difficulty by standardization of apparatus and equipment have already been taken by the A.S.T.M., it is desirable that a corresponding survey be made of all factors which are recognized as, or suspected of, influencing thermal conductivity in order that measurements made with an improved apparatus may be reasonably free from uncertainty arising from the constitution of the sample. Moreover, the results of such a survey are useful in indicating ways in which a refractory having certain desired properties can be produced, in pointing out variables which must be controlled in the manufacturing process to insure a uniform product, and as an aid in estimating the thermal conductivity of a material when no direct measurements are available. The purpose of this present survey is therefore to summarize the established principles of physics and chemistry bearing on the subject, comparing them and extending them, to collect the data recorded in the literature, and to supplement them with new measurements. As the data available are in many instances still incomplete and as their accuracy often leaves something to be desired, the conclusions derived must not be regarded as a final answer but rather as a step toward the solution of a complex and difficult problem.

The investigation starts with an examination of the concept of "thermal conductivity" itself. The definition of thermal conductivity is contained in the fundamental relation for heat flow in the steady state, that is, that the rate of flow of heat between two parallel isothermal planes of unit area and at unit distance apart is proportional to the temperature gradient between the planes. The proportionality factor, which is characteristic of the material through which the heat flows, is called the "thermal conductivity" of that material. It should be noted that this definition does not require the thermal conductivity to be independent of any variable, and the question of whether or not it varies with changing conditions can be settled only by experiment, and even then the answer depends to some extent on the accuracy of measurement. This point is emphasized because it has been somewhat obscured by the apparent success of the common assumptions that thermal conductivity is independent of temperature and heat flow. This success is, however, largely due to the circumstance that these assumptions are as accurate as most of the methods of measurement which have been used in the past and to the fact that scarcely anyone has attempted to make really precise calculations.

As it is not permissible to assume without experimental evidence that thermal conductivity is uninfluenced by any given variable, the following list has been made of all factors which seem likely to have an effect, and the general plan of this survey is to evaluate, in so far as is possible, the influence of a change in each variable when all the others are held sensibly constant:

FACTORS WHICH MAY INFLUENCE THE THERMAL CONDUCTIVITY OF NON-METALLIC MATERIALS

A. Chemical Composition
   1. Influence of molecular structure in pure compounds
   2. Influence of impurity

B. Physical Texture
   1. Porosity
      a. Total void space
      b. Size and shape of pores
      c. Size and shape of grains

[1] Those especially concerned with this very extensive paper may wish to determine the availability of copies of the manuscript, for review and preparation of discussion prior to the meeting. Write A.S.T.M. Headquarters.

[2] Research Laboratory, United States Steel Corp., Kearney, N. J.

2. Presence of a Vitreous or Liquid Phase
   a. Total amount of phase
   b. Distribution of phase
3. Development of bond in fired products
   a. Influence of time of firing
   b. Influence of temperature of firing
4. Anisotropy and directional effects

C. Temperature
D. Pressure, stress or strain
E. Heat flow

CHEMICAL COMPOSITION

The thermal conductivity of pore-free crystalline aggregates varies markedly with chemical composition, the best conductors, such as magnesia, having a conductivity some four to five times larger than that of the poorer conductors, such as olivine or mullite. In general, those compounds which have a simple molecular structure and which crystallize in a lattice of high symmetry, as for example, magnesia, which crystallizes in the isometric system, are better conductors than more complex compounds such as forsterite (magnesium silicate). Among the simpler compounds, the best conductors are those whose component atoms have most nearly the same weight and the same electronic structure. Moreover, the thermal conductivity of a given compound increases with increasing purity and in this respect is analogous to electrical conductivity. In most cases, a small amount of impurity present in a relatively pure material has a much greater effect than an equal addition to a material which is already impure.

PHYSICAL TEXTURE

Physical constitution has a larger influence on thermal conductivity than any other single variable. This is well illustrated by magnesia, which in the crystalline pore-free form is one of the best conductors among the refractory oxides, but in the form of powder ("precipitated magnesia") is one of the best refractory insulators. The effectiveness of the powder as an insulator is due to the presence of a film of air around each particle and is not a property of the magnesia itself; nevertheless, the difference in the conductivity of the two materials, which is of the order of a hundred fold, is a striking illustration of the influence of texture.

In considering physical constitution, two ideal structures are considered. The first is that of pores filled with air or glass embedded in a matrix of crystalline solid. This structure, which resembles that of a sponge, is termed the continuous-solid type. As a rough approximation it can be said that for this structure, thermal conductivity decreases linearly with increasing porosity and that the conductivity of the aggregate is but little influenced by the relative conductivity of the two phases. The second structure is that of crystalline particles separated by air or glass. It is essentially the structure of a powder and is called the continuous-air type. The conductivity of a material having this structure decreases approximately logarithmically with increasing porosity; moreover, the conductivity of the aggregate varies considerably with the ratio of the conductivity of the two phases. These conclusions based on physical principles are confirmed by experimental data. Most materials have a structure intermediate between the two ideal ones described, so that the change of conductivity with porosity lies between a linear and a logarithmic variation. The thermal conductivity of three-phase aggregates is also considered.

The conclusions just drawn are valid only when heat transfer takes place by true conduction alone. If there is in addition heat transfer by radiation or convection the situation is altered. When large pores are present and heat transfer by radiation is appreciable, the apparent "thermal conductivity" of the aggregate may even increase with porosity. This effect is most marked at high temperatures. If true conduction is considered, a change in size or shape of grains or pores produces only a second-order effect which is negligible compared with the effect of a change in total pore volume.

A special study is made of the influence of time and temperature of firing in the thermal conductivity of fired products. Two general changes may occur in firing: (1) Sintering or the formation of a ceramic bond which results in a more compact structure with a concomitant increase in thermal conductivity; (2) removal of volatile or combustible matter which results in a more porous, and therefore a more poorly conducting structure. Typical examples of each reaction are studied and in each case the change in conductivity appears to be exponential with time, that is, there is an initial rapid change followed by a relatively slow approach to a constant value at longer firing periods.

The data for the influence on conductivity of maximum temperature attained during firing are not very satisfactory but suffice to show that the thermal conductivity of the finished product increases markedly with this maximum temperature.

Directional effects are shown to be negligible in the great majority of commercial materials, although there are a few for which it must be considered, such as natural Sil-O-Cel blocks, insulating grills and, occasionally, expanded mica granules.

TEMPERATURE

One of the most striking differences between heat conduction in a crystalline solid and in an amorphous or vitreous body is that in a crystal the thermal conductivity is high at low temperature but decreases with increasing temperature whereas that of a glass or other amorphous body is relatively small at low temperature and increases with rising temperature. Although there are only a few materials other than glass which are amorphous in the strict sense of the word, there are a very large number which approach an amorphous condition, at least from a macroscopic point of view, and the conductivity of such materials increases with temperature. This group includes wools, powders, felted materials, insulating cements, and many refractories such as silica and fireclay brick. As a first approximation it can be said that for this group the increase of conductivity is linear with temperature up to about 2000 F. Above this temperature heat transfer by radiation becomes increasingly greater and the apparent "thermal conductivity" of the material increases more rapidly than is indicated by an extrapolation of the straight line obtained at lower temperatures.

On the other hand there are a few materials, chiefly those whose thermal conductivity is high, which have the properties of a crystalline material, and for these the conductivity decreases with rising temperature, except for temperatures below that of liquid air in which range the conductivity may increase with increasing temperature. This group includes recrystallized silicon carbide refractories, magnesite brick, and some chromite brick.

PRESSURE, STRESS AND STRAIN

Little is known about the influence of stress or strain upon the thermal conductivity of non-metallic materials, but there

is some evidence to indicate that stress or strain lowers the thermal conductivity of a body which has the characteristics of a crystalline material, that is, one whose conductivity decreases with increasing temperature. The effect on amorphous bodies is believed to be insignificant.

The only practical application in which thermal conductivity is likely to be influenced by hydrostatic pressure is that of a powder filled with air or other gas. If the pressure is reduced until the mean free path of the gas molecules becomes comparable with the distance between the particles of powder, the conductivity of the aggregate is greatly diminished. Until this point is reached, however, the conductivity of the aggregate is substantially independent of pressure.

HEAT FLOW

Examination of test data for over forty different refractory materials, including magnesia, chromite, fire clay, kaolin, mullite, and silica bricks, as well as insulating coverings, coatings, and cements, fails to give any indication of a variation of thermal conductivity with heat flow. A critical study of alleged examples of such a variation reported in the literature shows that there is as yet no well-established demonstration of its existence. A variation of thermal conductivity with heat flow is not impossible, but if it does occur it is either present in a few very special cases only, or is so small that it cannot be detected by present methods of measurement.

In conclusion, the several methods of reporting thermal conductivity, such as mean conductivity or true conductivity, are compared. Each method has some advantages so that all are likely to be used. Methods for converting one to the other are outlined.

1939 A.S.T.M. Regional Meeting, Columbus, Ohio, March 8

ABSTRACT OF PAPER ON

A Discussion of Test Methods for Determining the Physical Properties of Thermal Insulations[1]

By H. H. Rinehart[2]

THE standardization of tests is somewhat dependent upon the state of the science at the time of consideration. At present, there are many tests in use which effectually evaluate the qualities necessary for the proper performance of thermal insulations. Also, there are tests in use which indicate qualities that may not be necessary for the proper performance of thermal insulations. Some of these tests are duplications and modifications of tests used in testing both allied and dissimilar materials. Since the A.S.T.M. is the first authoritative body to attempt to standardize tests in this particular science, all tests related thereto are discussed in this paper. These are tabulated as follows:

Density	Toughness
Mixing	Compressive Strength
Consistency	Tensile Strength
Covering Capacity	Shear Strength
Adhesion to Steel	Durability
Cracking and Curling	Absorption
Hardness	Porosity
Flexural Strength	Permeability
Abrasion Resistance	Temperature Resistance

Corrosiveness

DENSITY

Plastic cements are usually sold on a weight basis, and the consumer is interested in the coverage obtained therefrom.

The loose densities of different types of plastic cements, before being mixed with water and molded, are not reliably proportional to the dry coverage obtained after they are trowelled or molded into place because:

1. Some cements contain materials which gel and swell when wet and remain in that expanded condition, or nearly so, upon drying.

2. Some cements contain materials which produce gases when mixed with water and cause considerable swelling of the cement.

3. Some materials pack and compress more than others when wet, and in many instances this is true for highly voluminous materials.

4. Some materials shrink when they are wet and retain this decreased volume upon drying.

Although the loose density is obtained with less effort, time and equipment than the covering capacity, it is apparent that the easier method is not indicative of the desired quality, namely, the dry molded coverage. Therefore, the loose density test for plastic cements could be eliminated unless it is found to be indicative of other important qualities more difficult to measure by other methods.

Preformed thermal insulation is usually sold on a board foot basis and therefore the customer's cost per unit of coverage is not dependent upon density. However the majority of consumers concern themselves with the density of this material, probably because of its influence upon design of equipment and its approximate indication of thermal conductivity.

The most common methods employed for determining the density of preformed thermal insulation are: (1) displacement in liquids, (2) displacement in sand, and (3) calculation from dimensional and weight measurements.

MIXING

At present, the mixing of plastic cements is generally accomplished by adding water and kneading the cement with the hands until the water is thoroughly mixed throughout the cement, and the optimum plasticity is obtained. This method may possibly be standardized by mixing with a machine or a mixing tool of some kind, or by specifying a definite procedure for the present practice of hand mixing.

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[1] DISCUSSION OF THIS PAPER IS INVITED, see Editor's note on page 29.

[2] Insulation Engineer, Johns-Manville Research Laboratories, Manville, N. J.

CONSISTENCY

Consistency is an important factor in preparing plastic cements for covering capacity tests. It is dependent upon the amount of water used and since the coverage also depends upon the amount of water used, covering capacity is dependent upon consistency. The inherent strength of the dry molded cement is somewhat dependent upon how much the cement has been extended by the addition of water. Within certain limits, adhesion is also dependent on the consistency or water content of plastic cements.

COVERING CAPACITY

Coverage is of utmost importance to the consumer because of its relation to the ultimate cost of plastic cement installations. Some of the present laboratory methods used in molding the wet cements closely simulate those used in field applications, while others show considerable departure therefrom. By the latter methods, the cement is placed in small deep molds which cause them to have fewer voids and less coverage than the former methods. Since there is a considerable range in the tendencies of various cements to form voids in molding and thus affect the coverage, some method of molding should be standardized.

From a research point of view, the method resulting in fewer voids would be desirable, but the method simulating field applications would be more indicative of the coverage to expect in field applications and not so misleading to the consumer.

ADHESION TO STEEL

Preformed thermal insulations are necessarily adhered to steel or other surface they are insulating by some adhesive or mechanical means. Plastic cements are applied in a wet plastic condition and their adherence is by virtue of their own adhesive properties and not by those of a separate adhesive or some mechanical method. Due to the natural adhesiveness of most materials suitable for use in plastic cements, the problem of adhesion has not been important and the demand for adhesion tests has been small.

CRACKING AND CURLING

Plastic cements are often applied over the outside surfaces of preformed thermal insulations after they are in service and heat has been applied. This application over the warm, dry preformed insulation causes the plastic cement to dry quite rapidly and gives it considerable tendency to crack and curl. The trade has never demanded a test for such characteristics and such tests have been used only as a guide in the development or improvement of plastic cements.

HARDNESS

Hardness tests afford an inexpensive and simple means of determining some qualities of a material. The resistance to indentation is the form of hardness test most often used. This resistance indicates the ability of a material, when well supported over its entire area, to carry concentrated loads, to resist denting and abrading, and there are possibilities of its giving indications of other desirable qualities.

The two most popular types of hardness tests used for various materials are: (1) resistance to indentation, and (2) the rebound imparted to a falling object (scleroscope). The indentation test has been found to be adaptable to thermal insulations and to simulate some of the most likely service conditions, while the rebound method would appear to be unsuitable for such comparatively soft materials.

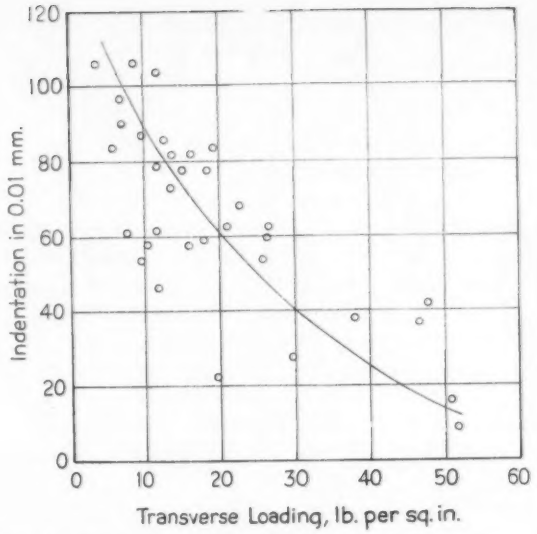

Fig. 1.—Relation Between Hardness, Expressed as Plastometer Indentation, and Transverse Loading.

Data are from tests on 34 different samples of a plastic insulation, prepared by varying the proportions of the same ingredients.

There are many possible variations of the indentation test, such as the size and shape of the penetrating pin, the amount and type of loading, time of penetration, units of measure, etc. Each of these variations has a decided effect on the quality of data obtained for different types of materials. Therefore, it appears necessary to determine the design of a penetrometer that will furnish consistent and correlative data for thermal insulations.

At present, the Pusey and Jones Plastometer, equipped with a $\frac{1}{8}$-in. spherical pointed penetrating pin, is widely used in testing thermal insulations. This plastometer was essentially designed for determining the hardness of rubber and possibly materials which are comparatively homogeneous or at least those with ingredients of a somewhat small and uniform particle size. In view of the non-homogeneous nature and the extreme variations in particle size of most thermal insulations, the results obtained with the plastometer are not sufficiently consistent and correlative with other properties to provide a definite relation therewith. This is demonstrated in Figs. 1 and 2. However, the data plotted on these charts show a distinct trend and location which indicates that there is a relation between indentation and some of the other properties. If the variations, which are undoubtedly due to the methods of test, are removed, the points on the chart will come closer together and curves having definite equations and relationships between properties will result. The range of the plastometer indentation readings on a small sample of a typical thermal insulation is unusually large and it is believed that a penetrometer device with the proper size, shape, and application of load will not show such extreme variations on a single sample but will indicate its true quality as related to service conditions.

FLEXURAL STRENGTH

There are very few instances where service conditions will impose transverse loading upon thermal insulations, for they

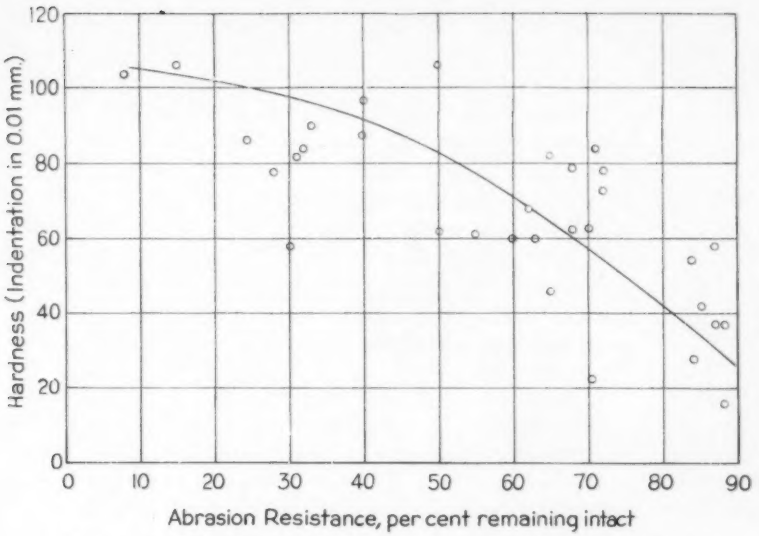

Fig. 2.—Relation Between Hardness, Expressed as Plastometer Indentation, and Abrasion Resistance.

Data are from tests on 33 different samples of a plastic insulation, prepared by varying the proportions of the same ingredients.

are usually supported over their entire area by the object which they are insulating. However, the preformed thermal insulations must have sufficient flexural strength to withstand handling during shipment and application. For non-ductile materials, the flexure test has been found to indicate strength, stiffness, and toughness. There appears to be considerable relation between flexural strength and hardness, also flexural strength and resistance to tumbling abrasion. However, there are variations as shown in Figs. 1 and 3, but these variations are most likely due to imperfect test methods.

ABRASION RESISTANCE

Occasionally, thermal insulations are subjected to abrasive actions such as escaping steam, flue gases, rubbing by movement of equipment, foot traffic, etc. Therefore, it is necessary for a good thermal insulation to be resistant to abrasive action, but other qualities may be criteria of abrasive resistance. Resistance to abrasion is dependent not only upon the hardness of the various ingredients in the insulation, but also upon the tenacity with which the binder clings to the fibers and other component parts of the insulation. Sliding abrasion has been found to be approximately proportional to hardness. Tumbling abrasion has been found to have an approximate relationship with hardness and flexural strength (Figs. 2 and 3). Although the data obtained do not give a smooth curve, the general trend and relationship can be easily recognized. The fact that a very definite relationship is not shown by the data obtained is probably due to imperfect test methods.

TOUGHNESS

In order to obtain the temperature resistance required of most thermal insulations, they are often of a comparatively crumbly or brittle nature. However, it is desirable to have a tough material with sufficient structural strength to withstand any shock, vibration, abrasion, or rough treatment that may be encountered in service.

Since the deflections of brittle specimens in the flexure test are considerable and easily measured, an accurate determination of flexibility and toughness may be obtained. However, thermal insulations on the open market vary in strength over a large range and some are quite soft and weak. In running flexure tests on the latter, it is difficult to determine where the "drop of beam" or yield point occurs, and even the ultimate strength is very hard to determine with exactness. It so happens that these weaker materials often excel in other desirable characteristics of a thermal insulation and it may not be advisable to sacrifice such materials for the sake of what appears to be a suitable test. Also, it is believed that toughness is generally relied upon to offer resistance to sudden shocks or blows received by thermal insulations in service.

"For measuring the abilities of materials to withstand sudden shocks or blows, experience has shown that none of the static tests is entirely suitable."[2] Such determinations can best be made under tests approximating the kind of loading which the material must withstand. Therefore, it would appear that toughness of thermal insulations may be determined more effectively by the dynamic type of test (suddenly applied loads) than by the static type of test (gradually applied loads).

COMPRESSIVE STRENGTH

Some thermal insulations are of such a nature that there is a rather well-defined point in the loading at which a complete disintegration of structure takes place, while others are of a soft and compressible nature and such a point cannot be observed. Nearly all thermal insulations have such poorly

[2] Materials of Construction, Johnson, Withey & Aston, Sixth Edition, John Wiley & Sons, Inc. (1926), page 124.

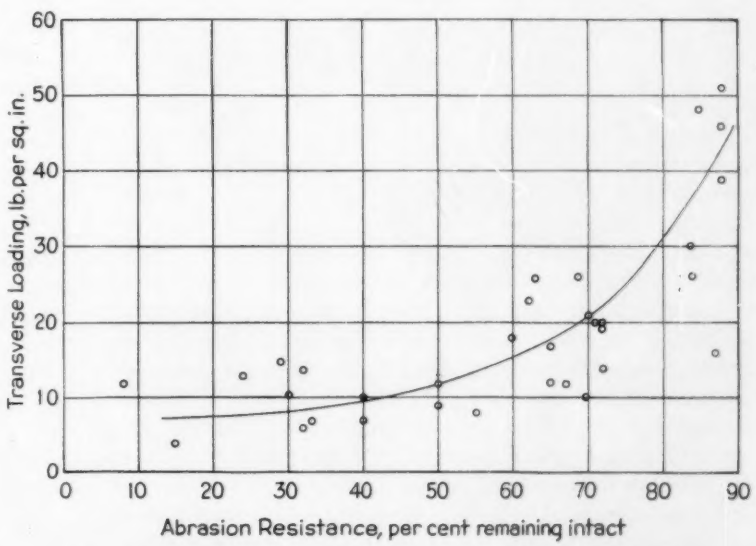

Fig. 3—Relation Between Transverse Loading and Abrasion Resistance.

Data are from tests on 33 different samples of a plastic insulation, prepared by varying the proportions of the same ingredients.

defined elastic limits that it is quite difficult to establish criteria of mechanical properties such as yield point, any of the moduli, etc. However, it is possible to base the compressive strength of thermal insulations upon the load sustained at a given unit of deformation. This unit of deformation can be expressed in per cent of thickness or directly in inches, but it should always be a function of the thickness. Values obtained by this method furnish a basis of comparison and are believed to be satisfactory.

TENSILE STRENGTH

Tension tests indicate strength, ductility, and toughness for ductile materials, but only strength is indicated for non-ductile materials such as thermal insulations. The ultimate strength is quite consistent for homogeneous materials and those having a high binder content or a uniform mechanical means of binding the particles together. This is due to all portions of the binding elements distorting more or less equally and uniformly until their limit is reached and the final break occurs. Thermal insulations are not homogeneous and necessarily contain various types, amounts and shapes of fibers, binders, etc. Therefore, all parts do not distort equally and the actual rupture occurs successively over many elementary portions of the broken section before the final failure takes place. This type of failure in some thermal insulations is also due to irregular wet to dry shrinkage which leaves considerable internal stresses in the body and causes some portions to come to their ultimate strength earlier than others, thus causing successive ruptures before the final break. Therefore, it would appear that the tension test is not entirely suitable for thermal insulations.

SHEAR STRENGTH

Service conditions seldom, if ever, subject thermal insulations to direct or transverse shear. About the only cases where thermal insulations are subjected to any shear stress are those of cross-bending and compression shear. The flexure test is far more important in relation to cross-bending than a direct shear test. Also, a proper indentation test would be far more important in connection with compression shear than a direct shear test. Direct shear is of practical importance in only a limited number of cases, such as in the design of riveted joints, bridge pins, crank pins, and short I-beams

DURABILITY

Most service conditions impose some sort of small vibrations or oscillating stresses on thermal insulations that are not imposed by the ordinary static or dynamic type of tests. The magnitude of these stresses may vary from those caused by small motors to those caused by huge turbines, rolling mills, and reciprocating engines. The actual strain exerted on the insulations by each one of these stresses is comparatively small but they are rapidly alternating or reversing from stress in one direction to stress in the opposite direction.

There are two possible types of fatigue failures in thermal insulations: (1) a general deterioration of cohesion, and (2) a localized failure confined to a very small portion of the member under stress. A test which would evaluate the first type is preferable because the latter would merely serve to indicate the weakest point in the specimen under test. Therefore, the type of failure should play an all-important part in the development and selection of a durability test for thermal insulations.

MOISTURE ABSORPTION

Obviously, moisture is not an important factor while thermal insulations are subjected to heat.

Thermal insulations for service at temperatures which will not cause evaporation of moisture should have a very low, if any, moisture absorption; otherwise the insulation could absorb and retain moisture with a consequent increase in thermal conductivity.

Present practice does not require thermal insulations to have a maximum moisture absorption, because in cases where moisture and water are factors, vapor barriers, moisture-proof coatings, and jackets are used.

POROSITY

There is possibly a relation between porosity and thermal conductivity, but at present this relation has not been definitely evaluated and therefore porosity cannot serve as an indication of thermal conductivity values. If and when such a relation is established, it will probably involve the type of voids and void spacing, for it is already known that isolated and closed voids have different effects on thermal conductivity than connected and open voids.

PERMEABILITY

It is possible that thermal efficiency may be related to the permeability to air, but since this relationship has not been definitely evaluated, the permeability cannot serve as an indication of thermal conductivity.

Thermal insulations are often used below ground, but their permeability to water in this case is not of great importance because it is necessary to exclude all free water by means of waterproof membranes and constructions; otherwise the thermal conductivity might be greatly increased.

TEMPERATURE RESISTANCE

The ability of a material to resist deterioration at elevated temperatures may be obtained by determining the effects of heat upon it. If the physical properties are determined before and after heating, the effects can be expressed in definite and standardized units of measure. Although it is possible to determine the effects of elevated temperatures on thermal insulations by many of the strength tests, it should be realized that in service the insulation is not subjected to elevated temperatures until after it is applied. Therefore, it will be subjected to only a very few of the stresses that are imposed by these various physical tests after being subjected to elevated temperatures. In view of the limited number of stresses to which the material will be subjected after application, it appears that the only tests to be used for measuring temperature resistance should be those which involve the stresses exerted after the insulation is subjected to elevated temperatures in service.

CORROSIVENESS

There has been some difficulty experienced in connection with corrosion caused by plastic cements. At present there is but one consumer who requires a corrosion test, and the amount of corrosion is determined by visual observation.

Evaluating corrosion by visual observation introduces personal error because adequate descriptions are difficult to make and a quantitative estimate is inaccurate.

There are numerous methods of measuring the corrosion of metals in free water, but those most suitable for measur-

ing corrosion of metal caused by application of wet cements appear to be:

1. Loss in weight of metal due to removal of products of corrosion.
2. Gain in weight due to products of corrosion.
3. Change in electrical resistance.
4. Depth of pitting.
5. Change in physical properties.

CONCLUSIONS

It appears desirable to establish standard methods of test for thermal insulations covering the following, some of which apply to plastic insulations and some to preformed:

1. Mixing procedure.
2. Preparation of sample for tests.
3. Dry molded density, expressed as such or as "dry coverage in board feet per 100 lb. of dry cement."
4. Temperature resistance.

Thought and study are necessary both as to the desirability of standards and methods to be employed regarding the following:

1. Consistency
2. Adhesion to Steel
3. Cracking and Curling
4. Absorption
5. Corrosiveness
6. Hardness
7. Flexural Strength
8. Abrasion Resistance
9. Toughness
10. Compressive Strength
11. Durability

It appears unnecessary to establish standards on the following properties:

1. Loose Density
2. Screen Analysis
3. Shear Strength
4. Tensile Strength
5. Porosity
6. Permeability

1939 A.S.T.M. Regional Meeting, Columbus, Ohio—March 8

ABSTRACT OF PAPER ON

One Consumer's Problems in Selecting Thermal Insulation[1]

By E. T. Cope[2] and W. F. Kinney[2]

THE study of thermal insulating materials in The Detroit Edison Co. began in 1922 when it was found that while 85 per cent magnesia covering performed satisfactorily at 575 F., at 780 F. the material disintegrated. This failure gave rise to the following questions: "What is the highest temperature the insulating material will withstand continuously?" and "What materials are available that will withstand continuously higher temperatures?" Before satisfactory answers could be found, test methods had to be devised for comparing competitive materials.

The purpose of this paper is to review the work done. For convenience, the paper is divided into two parts:

A. A review of the important problems encountered, including a brief description of the methods of test used.

B. Suggested procedure which would lead to a better understanding between producer and consumer.

A Review of the Important Problems

When this study of thermal insulation was begun, there were few published reports and no accepted standards which would help the prospective buyer. Manufacturers talked about thermal conductivity and density, whereas there were other important facts which the user required in making correct choice. The problems which our company has had to solve and others which have received constant attention will be treated individually.

Problem (a)—The Determination of the Maximum Continuous Operating Temperature Limit:

No recommended temperature limits had been published and no test methods described for determining the maximum temperature at which a specific material was practicable for a long period. The criteria selected in our program of investigation were the loss of weight and the loss of strength resulting from continuous heating. The materials tested included 85 per cent magnesia, high-temperature insulation, insulating cement, asbestos-felt covering, and blue asbestos fiber. Samples were heated continuously for 9000 hr. in specially built electrically heated ovens operating at 400, 500, 600, 700, 800, 900, and 1000 F. Weights of samples were determined after drying at 210 F. for 24 hr. and after heating at the oven temperatures for various intervals. Figures 1 and 2 show the progressive weight loss for one brand of 85 per cent magnesia and one brand of high-temperature material, respectively. Mechanical strength of the first samples inspected was determined by pinching between thumb and finger. This procedure was later augmented by tests to determine the change in flexural strength as indicated in Table I. The results of these tests failed to confirm the belief that the loss of weight is a measure of the loss of physical strength.

TABLE I.—DATA ON CHEMICAL AND PHYSICAL PROPERTIES OF THREE BRANDS OF HIGH-TEMPERATURE INSULATION BEFORE AND AFTER CONTINUOUS HEATING AT ELEVATED TEMPERATURES.

Chemical Composition, per cent by Weight[a]

	Brand A	Brand B	Brand C
Silicious matter including Asbestos and Plastic Clay	83.5	42.4	55.0
Calcium Carbonate	0.0	19.5	0.0
Basic Magnesium Carbonate	16.4	37.3	44.9

Loss of Weight During 9000 hr. Continuous Heating,[a] per cent

Temperature	Brand A	Brand B	Brand C
700 F	9	18	22
800 F	9.5	20	23
950 F	11.0	30	29.5

Flexural Strength, lb. per sq. in.

	Brand A	Brand B	Brand C
As received	59.2	72.0	65.5
After heating for 9000 hr. at 700 F	37.3	67.2	18.3
After heating for 9000 hr. at 800 F	31.2	53.4	6.5
After heating for 9000 hr. at 950 F	21.9	21.3	4.5

[a] Basic weight was that of samples dried for 24 hr. in air at 210 F.

[1] DISCUSSION OF THIS PAPER IS INVITED.—See Editor's Note on page 29.

[2] Research Dept., and Production Dept., respectively, The Detroit Edison Co., Detroit, Mich.

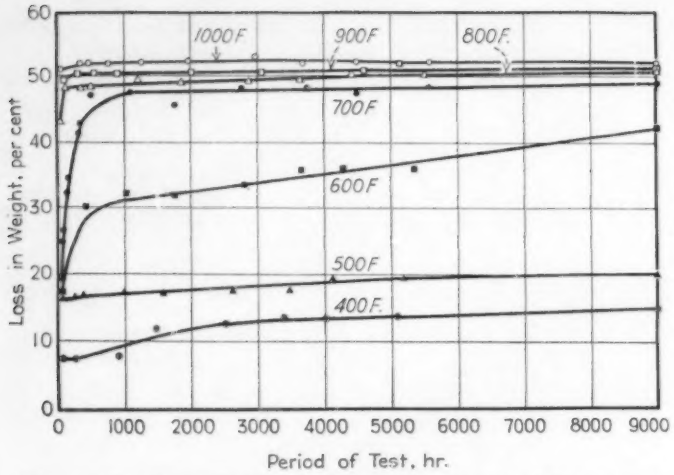

Fig. 1.—Results of Prolonged Heating One Brand of 85 per cent Magnesia

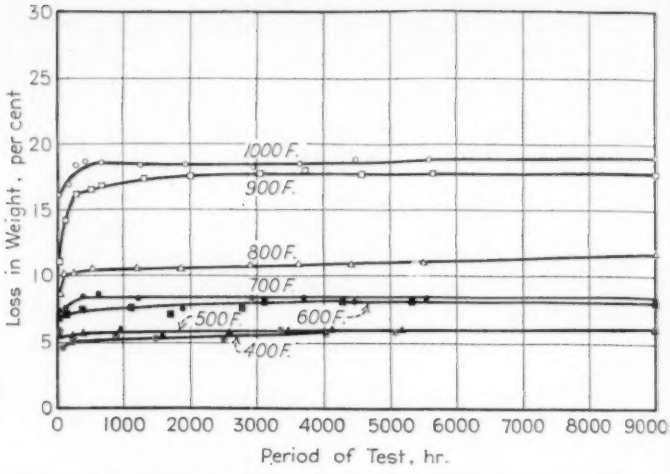

Fig. 2.—Results of Prolonged Heating One Brand of High-Temperature Insulating Material

Recently the authors have studied this problem as it applies to materials used for insulating pads for high-temperature turbines. Field tests on sample pads were conducted to determine the performance of various types of fabrics and fillers when installed on pipes carrying steam at 825, 925, and 1050 F. for several months. In many instances the fabric in contact with the hot pipe lost its fibrous form and some fillers disintegrated.

Problem (b)—Development of Methods for Testing Physical Properties:

It is obvious that there are several physical characteristics of insulating materials for which test methods might be developed and whose determination might be desirable if the significance of such values were established. Some of these characteristics, applying particularly to preformed materials, are: flexural strength, already referred to, compressive strength, toughness, abrasion resistance, impact resistance, and surface hardness. Of these, flexural strength is the only characteristic for which tests have thus far been performed by the authors' company. Values for this characteristic have proved to be of considerable importance in comparing preformed materials. The similarity between this test and the loading which the material must withstand during handling encourages its use. However, the dimensions and preparation of test specimens, rate of loading, etc., have not been standardized. The safeguard employed has been to test competitive brands using specimens having the same dimensions and similarly loaded.

There are other kinds of loading imposed during handling, such as occur when crated materials are dropped or rolled over, resulting in shipments arriving as shown in Fig. 3.

Concerning insulating cements and plastic insulation, information on resistance to deterioration at working temperature was augmented by tests for caustic alkali, trowel-ability and air-drying shrinkage. No quantitative evaluation of trowel-ability has been devised because the condition of the surface of wet or dried cement is difficult to measure. An experienced pipe coverer judges the ease with which the wet mixture can be troweled to a smooth, scratch-free surface. In determining shrinkage this material is air-dried, then oven-dried at 210 F. for 24 hr. and the volume when dry is determined by displacement to obtain linear shrinkage and dried coverage.

Problem (c)—Determination of Economic Thickness of Insulation:

The determination of the economic thickness of insulation for temperatures from 300 to 800 F. was studied simultaneously with Problem (a). Although manufacturers had published schedules of thicknesses based on data obtained in cooperative tests or on results of individual laboratory studies, it was felt desirable to undertake the determination of the economic thicknesses applying to our own conditions. Calculations of economic thickness were carried out for various pipe sizes operating at different temperatures. Net cost of materials and thermal conductivity values were furnished by vendors, and cost of labor and heat came from the company's records. The procedure is detailed in a paper "The Rational Design of Covering for Pipes Carrying Steam up to 800 F. by W. A. Carter and E. T. Cope, published in *Transactions*, Am. Soc. Mechanical Engrs., 1925. Results for one set of conditions are shown in Fig. 4.

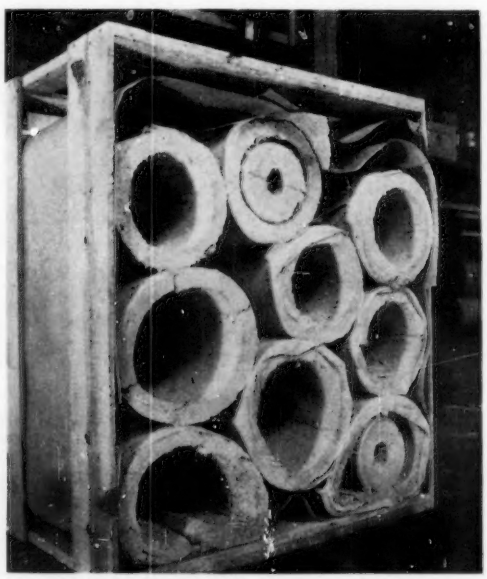

Fig. 3.—Covering Damaged in Transit.

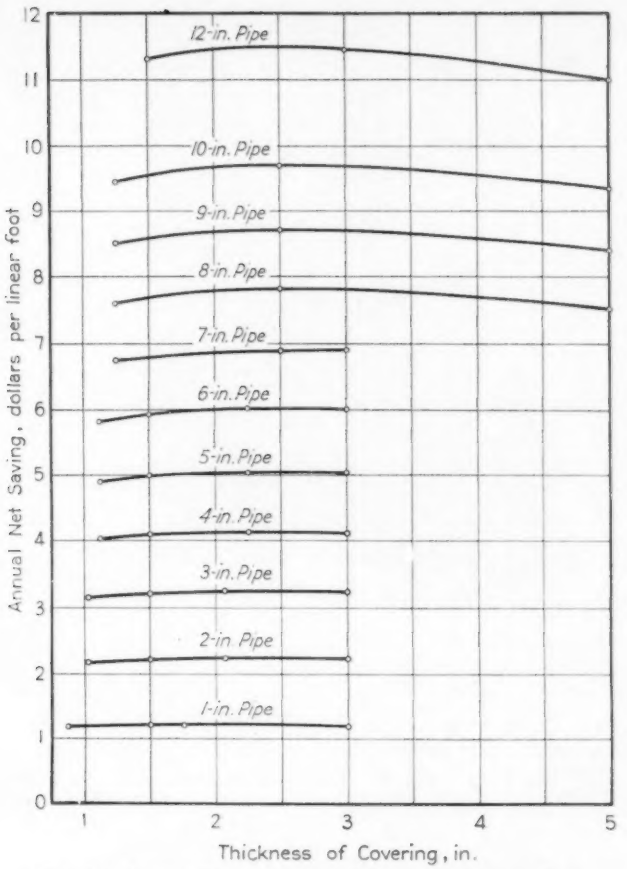

Fig. 4.—Annual Net Saving in Dollars per Linear Foot.

85 per cent magnesia covering—steam temperature = 440 F., heat cost = $0.35 per million B.t.u.

TABLE II.—CALCULATED AND MEASURED TEMPERATURES OF A 16-IN. PIPE CARRYING STEAM AT 715 F. AND COVERED WITH 4 IN. OF INSULATION.

	Temperature of Pipe, deg. Fahr.	*Temperature of Outside Surface of Covering, deg. Fahr.*
Used in design	720	132
Obtained from pipe	715	129

The close agreement between anticipated and achieved temperatures, as shown for one case in Table II, demonstrated the correctness of: first, calculated rate of heat loss; second, values of thermal conductivity used; and, third, method of installation. Tables of thicknesses furnished by producers usually do not take account of variations in costs of labor, heat and fixed charges. Therefore, anyone wishing to check the thickness required under any set of conditions will find valuable use for a chart devised by the late L. B. McMillan and published in a paper, "Selection of Insulation for Steam Distribution Systems," *Proceedings*, National District Heating Association, 1927.

Problem (d)—Correct Basis for Choice Among Materials:

The results of an economic study of three kinds of insulation, shown in Fig. 5, revealed an insignificant difference in annual net saving between the lowest and the highest. In this instance, the characteristic which decided the issue was the ease of installation. This decision was made not by engineers who designed the covering but by the workmen who were to install it.

Insulating plastics present another phase of this problem of choice. There are two distinct classes of these materials: plastic insulation and insulating cement. Plastic insulation consists of long-fiber asbestos, rock or glass wool, or expanded mica, with a binder, and possesses good insulating value. Insulating cements are used for finish on other insulation. They should be readily trowelable to a firm, smooth finish free from drying cracks, must contain no caustic, and must not deteriorate at service temperature. Recently the authors examined, tested, and judged several brands of insulating cement. The demands imposed called for tests to determine: (1) Maximum operating temperature; (2) trowel-ability; (3) linear shrinkage; (4) causticity. Coverage and cost per unit area were calculated from values obtained in the tests. The nature of the problem involved in choosing from a group of cements offered for a given service can be appreciated by examining Table III.

TABLE III.—CHARACTERISTICS OF SEVEN BRANDS OF INSULATING CEMENT.

Brand	*Trowel-ability*	*Average Linear Shrinkage, per cent*	*Caustic Alkalinity*	*Coverage dry, sq. ft. 1 in. thick per 100 lb.*	*Cost per sq. ft. 1 in. thick, dry, cents*[b]
A	Good	18.44	None	17.6	9.9
B	Good	21.4	None	17.0	5.3
C	Good	11.5	Trace	26.6	6.3
D	Good	21.9	None	19.4	9.9
E	Good	19.4	None	20.2	6.2
F	Fair[a]	2.6	None	25.9	7.9
G	Good	20.0	None	17.2	13.7

[a] Cement set so rapidly that troweling was difficult.
[b] The price per ton used was that quoted in 1937.

All materials were capable of withstanding the temperatures involved. In choosing from among these brands, the presence of caustic eliminated brand C, while "fair" trowelability threw out brand F. Selection was finally made between brands A and E because of comparatively low shrinkage, this being one of the characteristics thought important. These two brands appeared most promising even though brand A

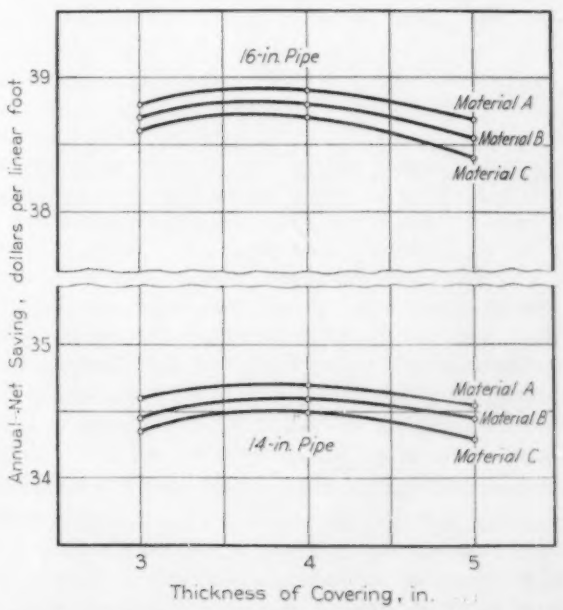

Fig. 5.—Annual Net Saving in Dollars per Linear Foot

Three brands of covering—steam temperature = 720 F., heat cost = $0.35 per million B.t.u.

was above the group average in unit cost. To augment such laboratory tests, field trials are being conducted by construction men who will observe the behavior of the materials in actual service and will express their preference.

Problem (e)—Advantageous Disposal of Second-Hand Insulation:

During the dismantling of two obsolete power houses, a considerable quantity of 85 per cent magnesia was removed. It appeared to have value so was not discarded. A study showed that the material could be recast into blocks of desirable size and ample strength. The details of this procedure are included in E. T. Cope's article, "Detroit Edison Salvages One Hundred Fifty Tons of Insulation."

Problem (f)—Lack of Agreement Between Sample and Shipment:

The lack of agreement between the submitted sample and the actual shipment is an annoying problem which arises in purchasing and it can best be illustrated by relating an experience. A sample of insulating cement was submitted for test. Shrinkage, price, and coverage were satisfactory and it contained no caustic. When an order was used in the field, complaints were received that the material irritated the workmen's hands. A check test revealed a considerable caustic content and a markedly greater amount of shrinkage than shown by the sample. Needless to say, the entire shipment was rejected.

Problem (g)—Lack of Uniformity in Composition and Quality of Materials Supplied:

Lack of uniformity in composition and quality becomes immediately apparent to workmen, and whether the fault lies with manufacturing methods and inspection, variations in composition, or changes in the quality of ingredients unknown to the manufacturer, the result is a weakening of the user's confidence.

Problem (h)—Need for Additional Materials for Underground Steam Piping:

With the usual insulation installed on pipe in concrete box-type underground steam distribution ducts, it is extremely difficult to prevent water from penetrating the covering during occasional flooding of trenches. The boiling of the flood water around the pipe during submerged conditions affects many kinds of insulation in the manner shown in Fig. 6. Often the insulation is disintegrated and falls apart. Sometimes it is split due to the steam pressure evolved. In either case, the insulating value of the covering is destroyed, condensation losses increase, the anticipated saving in heat is not realized and repairs are difficult and expensive because of the construction.

Suggested Procedure Which Would Lead to a Better Understanding Between Producer and Consumer

Agreement regarding the significance of the various characteristics of insulating materials should form a basis for a better understanding between producers and consumers. The consumer buys insulation to save money by reducing the loss of heat. However, the savings must suffice to provide for the fixed charges on his investment, and any resulting improvement in operating conditions must not be too costly. To this end, the desired characteristics for the intended service should be carefully chosen and proper tests applied to insure satisfactory performance.

Fig. 6.—Damage from Flooding

The most important characteristic is permanence of the material at operating temperature. If the material deteriorates at the temperature involved, no other property matters. The user is interested in temperature resistance tests which have been carried on long enough to furnish convincing evidence that the material will not disintegrate during the useful life of the equipment on which it has been installed.

The material must be of such physical strength, mainly flexural strength, that it will withstand reasonable handling in transit and on the job. How strong, hard, or tough the material should be is a matter on which the user and producer should agree after thorough investigation, taking counsel of the men who are responsible for assembling the materials in the field.

So far, thermal conductivity has been mentioned only briefly. This is not due to any lack of interest or understanding of its significance. Its determination is regarded as beyond the ability of ordinary testing laboratory personnel and equipment. The determination of thermal conductivity should be thoroughly studied by producers and consumers together to develop the best possible testing technique. Only by the use of dependable values can the user expect to obtain the anticipated return on his insulation dollar.

The choice of the proper thickness of thermal insulation to be applied in any given case requires the use of accurate data on cost of heat, net cost of material, cost of labor per unit of area insulated, temperature of the surroundings, thermal conductivities, and expected rate of return on the investment. The McMillan chart is perhaps the most convenient means of verifying the economic thickness of covering that may be suitable for any particular conditions.

Correct choice between competitive products depends largely on the possession of accurate data regarding the physical and thermal characteristics of each material offered. The various characteristics must be considered and assigned their proper weight depending on the intended service conditions.

When this procedure is followed, both producer and user are benefited.

Conclusions

The complete paper describes the problems which one user of thermal insulation has met and has solved in a manner which has been reasonably satisfactory to himself and fair to manufacturers and vendors. This consumer was virtually obliged to solve these problems alone because there are, as yet, no generally accepted specifications or methods of test for ascertaining the suitability of the materials offered for a given service.

Certain problems pertaining to the selection of thermal insulation have been studied, as a result of which it has become apparent to the authors that some characteristics are more important than others. The following lists indicate the order of importance, the most important being given first:

Preformed Material: (1) Resistance to deterioration at working temperature; (2) resistance to breakage; (3) thermal conductivity; (4) ease of handling; (5) advantageous disposal of second-hand material.

Uniformed Material: (1) Resistance to deterioration at working temperature; (2) absence of caustic alkalinity; (3) trowel-ability; (4) air-drying shrinkage; (5) thermal conductivity.

In order that the producers and the users may find a basis for better understanding it is believed that the important step is the establishment of the significance of the physical characteristics for the various kinds and classes of thermal insulation and mutual agreement on methods of test.

Finally, the writing of specifications and the agreement regarding test methods does not answer the problem with finality, nor does this standardization preclude the necessity for constant attention to other problems, such as the study of suitable methods of installation and the investigation of newly developed products which may show promise.

1939 Regional Meeting, Columbus, Ohio—March 8

ABSTRACT OF PAPER ON

The Effect of Solar Radiation on the Heat Transmission Through Walls[1]

By F. C. Houghten,[2] Carl Gutberlet[2] and Albert A. Rosenberg[2]

From the Research Laboratory of the American Society of Heating and Ventilating Engineers, by approval of the A.S.H.V.E. Committee on Research, Walter L. Fleisher,[3] Chairman, and the Research Technical Advisory Committee on Cooling Load in Summer Air Conditioning, J. H. Walker,[4] Chairman.

WHILE our technical knowledge and understanding of the conductivity of building materials, methods for determining the same, and the resulting effect on heat transfer through walls built up of such materials for steady state conditions were being perfected, other factors such as condensation of moisture within the wall, the effect of heat capacity of the structure, and the wide departures from steady state flow encountered in applications to summer cooling and air conditioning have confronted the industry. As a result, new problems have arisen making necessary extended research and the development of new or modified testing procedure. The variable nature of the heat flow from a winter-heated and air-conditioned space to the outside, the flow from the outside into an unconditioned space in the summer, and the flow into a summer-cooled and air-conditioned space must be taken into consideration.

Only for steady state or equilibrium conditions is the heat flow through a wall per unit time equal to the product of the transmittance coefficient, U, the area, and the temperature difference between the air on the warm and cold sides. That is, this relationship is true only when the temperature difference between the two sides of the wall, made up of its various materials, remains constant for a sufficient length of time so that the rate of flow at all points throughout the thickness of the wall is the same, or when equilibrium exists between the rate of heat entering the warm side of the wall and the rate of heat flowing from the cold side. Of course, this ideal condition never exists even under most favorable heating practice. Granted that the inside temperature may be kept constant throughout the 24-hr. period, still there is a daily cyclic change in the outside temperature, which may be increased by solar radiation impinging directly against the structure. However, the temperature difference between night and day during the heating season is very seldom as large a percentage of the total temperature difference from day to day as is the case in the summer; and further, sun radiation plays an important part during the winter tending to lessen the maximum heating load for which the heating system must be designed. Therefore, the importance of unsteady heat flow during the heating season is less noticeable than is the case in the summer.

With increase in the importance of the application of summer cooling and air conditioning to buildings, the effect of variations from steady state flow becomes apparent. Assuming a desirable indoor dry-bulb temperature of from 78 to 80 F., there are few nights when the outside temperature exceeds this level, and then by only a relatively few degrees; so that without considering the direct effect of solar radiation the temperature head producing heat flow against which the insulation is applied may be assumed to vary from a maximum of 15 or 20 F. at midday to zero at night, or the 24-hr. variation is approximately 200 per cent of the average temperature head.

[1] DISCUSSION OF THIS PAPER IS INVITED.—See Editor's Note on page 29.

[2] Director, Research Assistant, and Research Engineer, respectively, Research Laboratory, American Society of Heating and Ventilating Engineers, Pittsburgh, Pa.

[3] Consulting Engineer, New York City.

[4] Superintendent, Central Heating Division, The Detroit Edison Co., Detroit, Mich.

However, during the summer direct solar radiation usually causes the outside wall surface temperature to rise considerably above the outside air temperature. Therefore instead of having to deal only with a high outside air temperature of from 95 to 100 F., it becomes necessary to consider the outside wall surface temperature, frequently rising to as high as 140 F., and a maximum of 160 F. having been observed on occasion. That is, there may well be a variation in temperature head producing heat flow from the outside into the building, ranging from zero at night to from 60 to 80 F. sometime during the day when the sun radiation is most effective. Under these conditions the assumption of steady state flow is so erroneous as to be absolutely useless to the designing engineer.

Thermal conductivity as a physical property of a building material, and transmittance coefficients for built-up walls have been determined and are tabulated in most treatises on design data used by designing engineers. The former coefficients have been determined largely by a standardized guarded hot plate test, in which constant temperatures on the two surfaces of a slab of the material are maintained, while the heat flowing through a given area is applied and measured electrically. Transmittance coefficients are quite similarly determined in some form of a guarded hot box in which predetermined constant air temperatures are maintained on the two sides of a section of the wall in question, while heat flowing through the wall is applied to the air and measured electrically. It was not until about 1920 that the application of these steady state coefficients under all conditions was questioned.

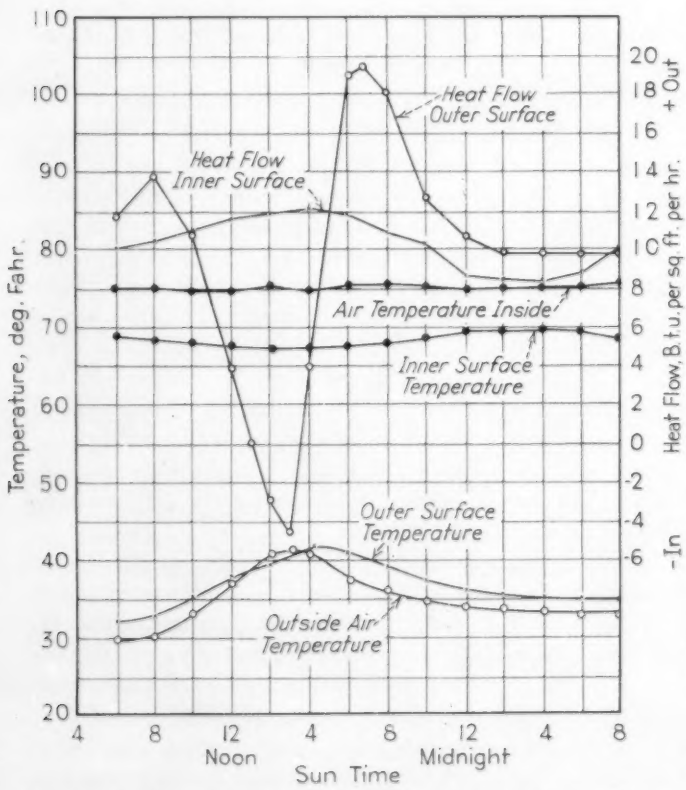

Fig. 1.—Northeast Wall—Grant Building, Pittsburgh, Pa., During January, 1934

Construction outside to inside: 4-in. brick veneer, 8-in. hollow tile, plaster. Transmittance coefficient $U = 0.256$, heat capacity = 16.94 B.t.u. per sq. ft. per deg. Fahr.

The American Society of Heating and Ventilating Engineers' Research Laboratory, in cooperation with the Pennsylvania State College Engineering Experiment Station[5], developed an application of the guarded hot plate for making determinations of the actual instantaneous rates of heat flow through walls under ordinary outside weather and inside heating conditions. Continuing this program, the A.S.H.V.E. Research Laboratory conceived[6] and later perfected[7] the Nicholls Heat Flow Meter, a relatively simple instrument which can be applied to any wall surface or built into the wall itself for determining the instantaneous rates of heat flow at these points. This development gave a valuable method for investigating the variable heat flow through building construction under natural weather conditions, which during the following years added much to the information on this subject.

Figure 1, taken from one of these studies, is characteristic of the variations during the winter in temperatures and heat flow for a typical wall unaffected by direct sun radiation, with a uniformly heated atmosphere within, and with normal weather conditions outside. The day on which these observations were made was rather unusual in that there was little change in the outside air temperature beyond that resulting from the diurnal cycle. The average temperature for the 24-hr. period was 35.5 F. with maximum and minimum of 41.5 and 29.8 F., respectively. The air-to-air temperature difference from the inside to outside ranged from 33.3 to 45.2 F., or approximately 30 per cent difference. The heat flow through the inside surface of the wall, which is the only heat flow of importance, averaged 10 B.t.u. per sq. ft. per hr. with a maximum and minimum of 12.1 and 8.2 B.t.u., respectively. It is of particular interest to note that the minimum heat flow from the interior, caused by the high temperature of midday, lagged about 13 hr. behind the maximum outside air temperature. The variation in heat flow from the outer surface of the wall was very great, and was reversed for a short time near midday, when the outside air temperature rose above that of the outside wall surface temperature.

Figure 2, taken from another study, gives typical temperature and heat flow variations throughout a 24-hr. period in the summer for a horizontal roof of an uncooled space affected by sun radiation.

In Fig. 3 is presented a log of observed conditions of temperature and heat flow for a wall of southeastern exposure having the same construction as that represented in Fig. 1. In this case, however, the inside was cooled to a constant temperature throughout the 24-hr. period. The average outside temperature for the 24-hr. period, starting at 6:00 a.m., was 84.7 F., while the maximum and minimum were 94.1 and 71.3 F., respectively.

A Nicholls heat flow meter was attached only to the inside surface of this wall, giving the curve of heat flow through the surface labelled "heat flow (measured)." In calculating

[5] F. C. Houghten and A. J. Wood, "A New Thermal Testing Plate for Conduction and Surface Transmission," *Transactions*, Am. Soc. Heating and Ventilating Engrs., Vol. 27, p. 385 (1921).

[6] F. C. Houghten, "A Study in Heat Transmission with Special Reference to Building Materials," *Transactions*, Am. Soc. Heating and Ventilating Engrs., Vol. 28, p. 81 (1922).

[7] P. Nicholls, "Measuring Heat Transmission in Building Structures, and a Heat Transmission Meter," *Transactions*, Am. Soc. Heating and Ventilating Engrs., Vol. 30, p. 65 (1924).

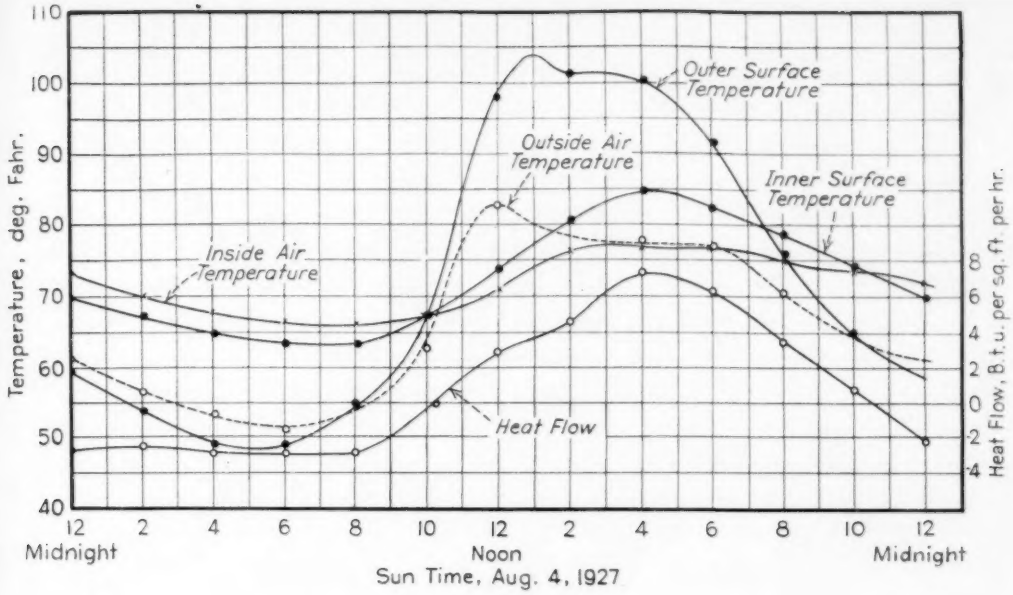

Fig. 2—Horizontal Roof—Mine Safety Appliance Company, Pittsburgh, Pa.

Construction outside to inside: slag and tar, 5-ply roofing, 1¼-in. tongue-and-grooved yellow pine. Transmittance coefficient $U = 0.293$, heat capacity = 2.91 B.t.u. per sq. ft. per deg. Fahr.

this heat flow the application of the Fourier Series analysis gave the results indicated by the curve "heat flow (calculated)."

While the calculated curve fits the measured one fairly well, it gives too high an average value, which probably results from some error in the assumptions. In this connection, it should be noted that the assumption of the conductivity, density, and specific heat, together with the distribution of these materials, is very important and must be known more accurately than can usually be determined from handbook data. The curves in Fig. 2 differ from those in Fig. 3 primarily due to the fact that the inside air temperature for the former case was not maintained constant, but was allowed to fluctuate depending upon the outside weather conditions and the rate of heat transfer.

Since 1932, the Technical Advisory Committee on Cooling Load in Summer Air Conditioning of the Committee on Research of the American Society of Heating and Ventilating Engineers has been interested in a number of studies concerning the factors governing the rate and variation in the

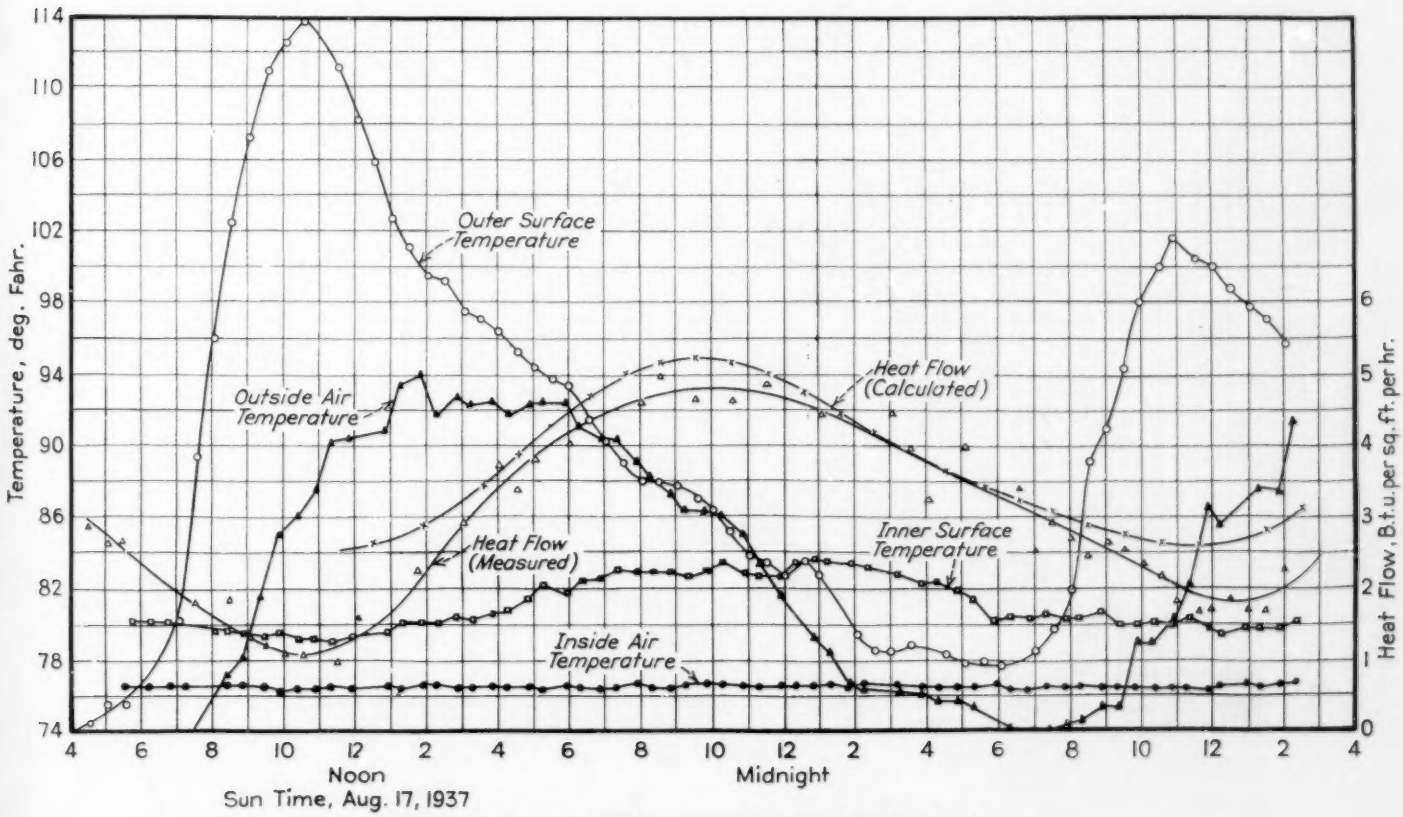

Fig. 3.—Southeast Wall—Grant Building, Pittsburgh, Pa.

Construction outside to inside: 4-in. brick, 8-in. tile and plaster. Transmittance coefficient $U = 0.256$, heat capacity = 16.94 B.t.u. per sq. ft. per deg. Fahr.

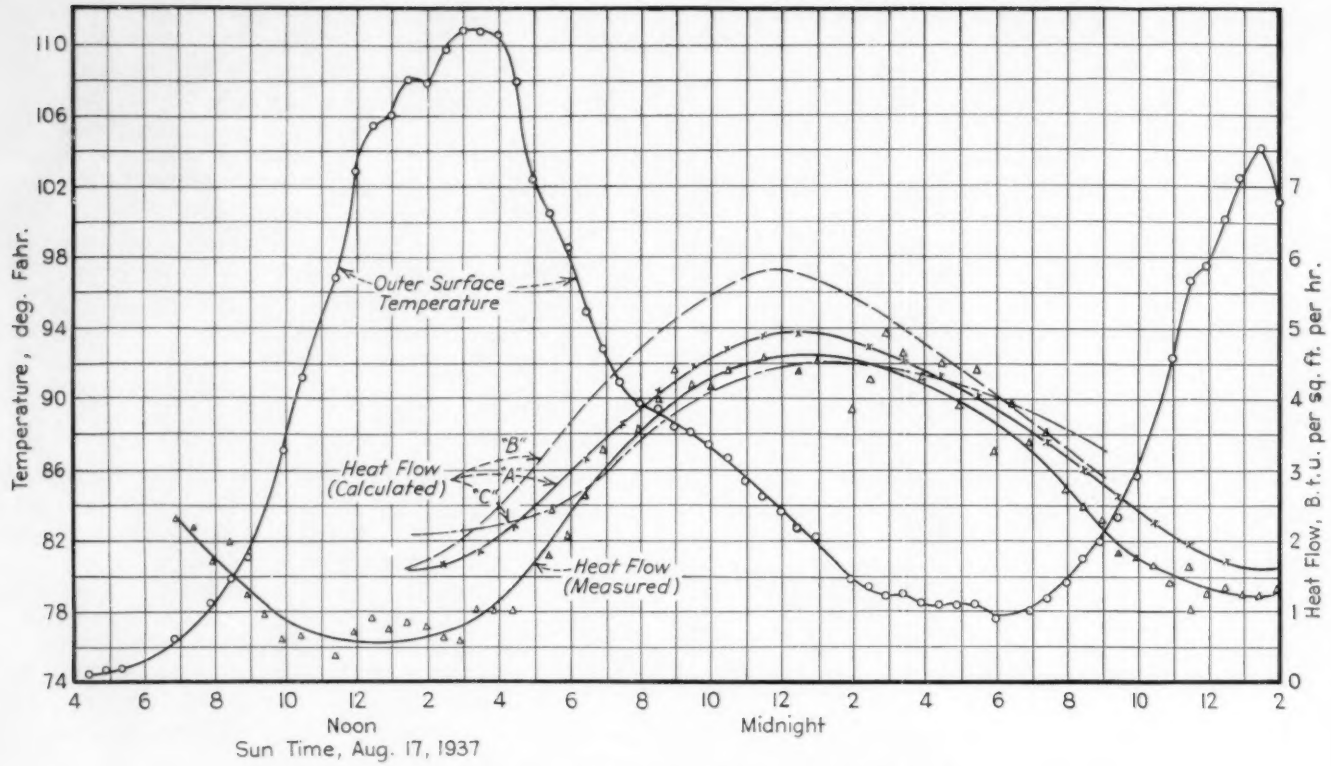

Fig. 4.—Southwest Wall—Grant Building, Pittsburgh, Pa.

Construction outside to inside: 4-in. brick, 8-in. tile and plaster. Calculated curve *A*, based on accepted assumption of transmittance coefficient $U = 0.256$, heat capacity = 16.94 B.t.u. per sq. ft. per deg. Fahr.: Curve *B* based on transmittance coefficient $U = 0.282$, heat capacity = 16.94 B.t.u. per sq. ft. per deg. Fahr.: Curve *C* based on transmittance coefficient $U = 0.256$, heat capacity = 18.63 B.t.u. per sq. ft. per deg. Fahr.

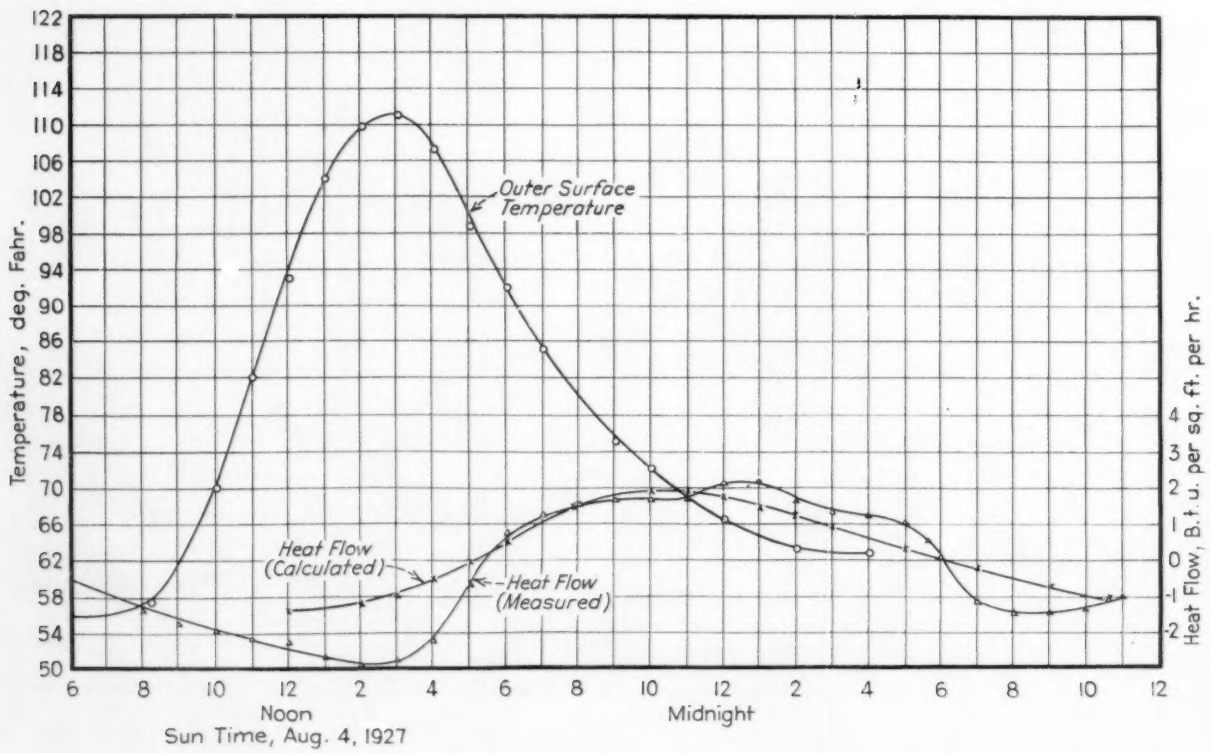

Fig. 5.—Horizontal Cinder Fill Roof—Mine Safety Appliance Co., Pittsburgh, Pa.

Construction outside to inside: waterproofing, 1½ in. concrete, 4-in. cinders and 1½-in. concrete. Transmittance coefficient $U = 0.161$, heat capacity = 11.24 B.t.u. per sq. ft. per deg. Fahr.

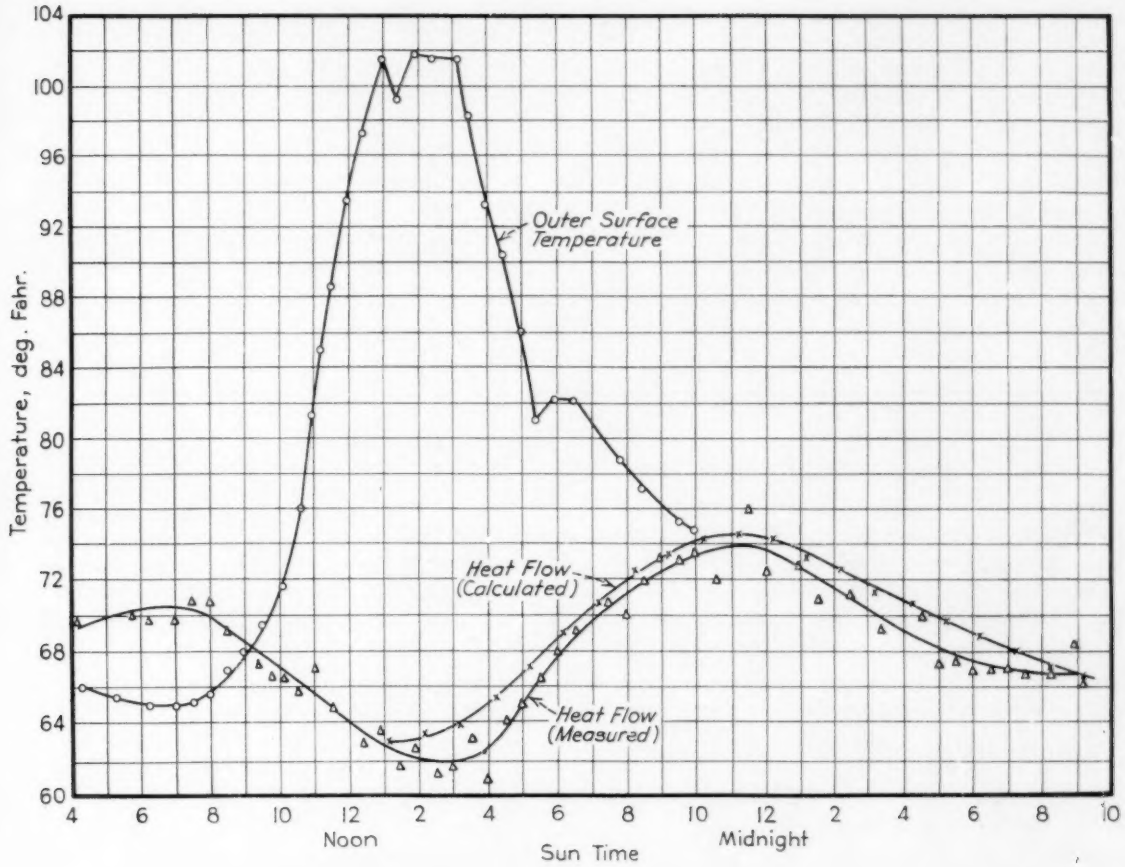

Fig. 6—South Wall — Oliver Ave. Building, Pittsburgh, Pa.
Construction outside to inside: 13-in. brick wall and plaster. Transmittance coefficient $U = 0.288$, heat capacity = 25.55 B.t.u. per sq. ft. per deg. Fahr.

rate of heat transfer into a summer air-conditioned space with prevailing weather conditions and sun radiation on the outside. Figures 4 to 13 give some temperature and heat flow cycles under different conditions. These show a maximum outside air or wall surface temperature at some time during the day, depending upon the direction of the exposure, followed by a rapid and later by a less rapid decrease in this temperature until a minimum is reached just before sunrise the following morning. The inside surface temperature, particularly with a constantly controlled inside air temperature, shows a similar but very much reduced cyclic change, lagging considerably behind the outside temperature curve. The heat flow curves for inside surfaces, and in some cases for the outside surfaces, were determined from observation by the Nicholls heat flow meters applied to these surfaces, and show rates of heat flow which are frequently not consistent with each other; that is, at the same time heat may flow into each surface or out of each surface simultaneously. The curve most useful to the engineer in determining the cooling capacity necessary for an air-condi-

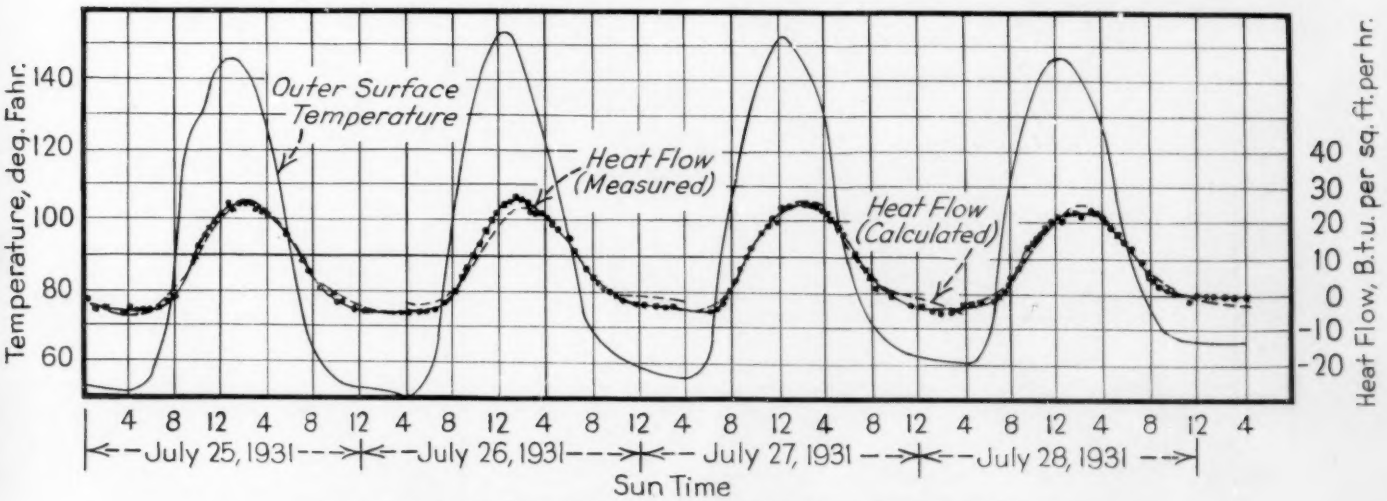

Fig. 7.—Horizontal Roof (Test Panel) A. S. H. V. E. Research Laboratory
Construction outside to inside: waterproofing and 2-in. pine. Transmittance coefficient $U = 0.265$, heat capacity = 3.14 B.t.u. per sq. ft. per deg. Fahr.

tioning system is the one giving the instantaneous rate of heat flow through the inside surface of the wall construction. From the charts presented it is readily seen that this curve, for any construction or any particular weather condition, cannot in any way be predicted from the steady state heat transfer coefficients.

It is interesting to note the relative significance of changes in thermal conductivity and changes in thermal capacity as they affect the heat flow into a space under intermittent conditions, as results from cyclic heat flow due to solar radiation. The effect of these two factors is shown in Fig. 4, in which two additional "heat flow (calculated)" curves, *B* and *C*, have been inserted for comparison purposes.

While the three iron and cork roof decks illustrated in Fig. 12 do not represent practical construction used in the field, they do indicate and perhaps exaggerate the variations which exist. The violent fluctuations indicated for the heat flow through the outside surface resulted from intermittent wind velocities and the interception of solar radiation by a few clouds.

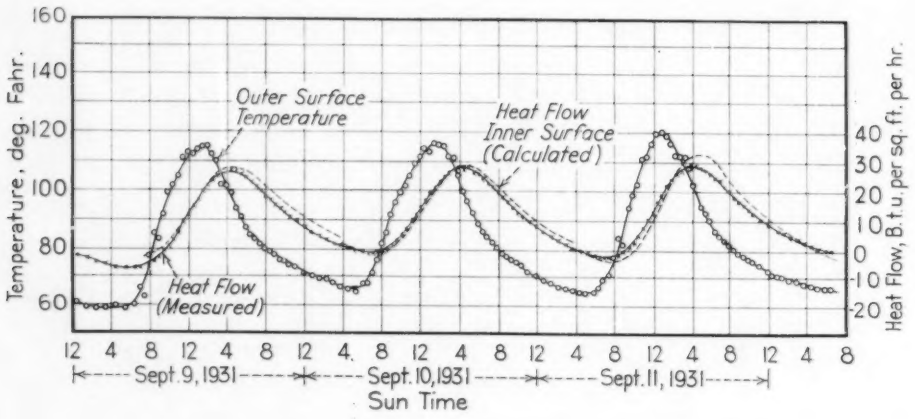

Fig. 8.—Horizontal Roof (Test Panel) A. S. H. V. E. Research Laboratory, Pittsburgh, Pa.

Construction outside to inside: waterproofing and 6-in. concrete. Transmittance coefficient $U = 0.682$, heat capacity = 17.62 B.t.u. per sq. ft. per deg. Fahr.

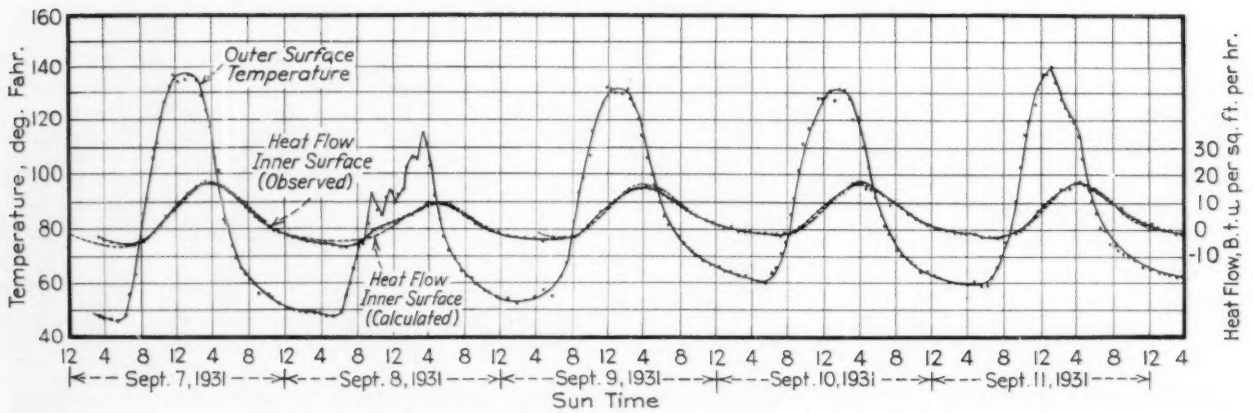

Fig. 9.—Horizontal Roof (Test Panel) A. S. H. V. E. Research Laboratory, Pittsburgh, Pa.

Construction outside to inside: waterproofing and 4-in. gypsum. Transmittance coefficient $U = 0.278$, heat capacity = 5.30 B.t.u. per sq. ft. per deg. Fahr.

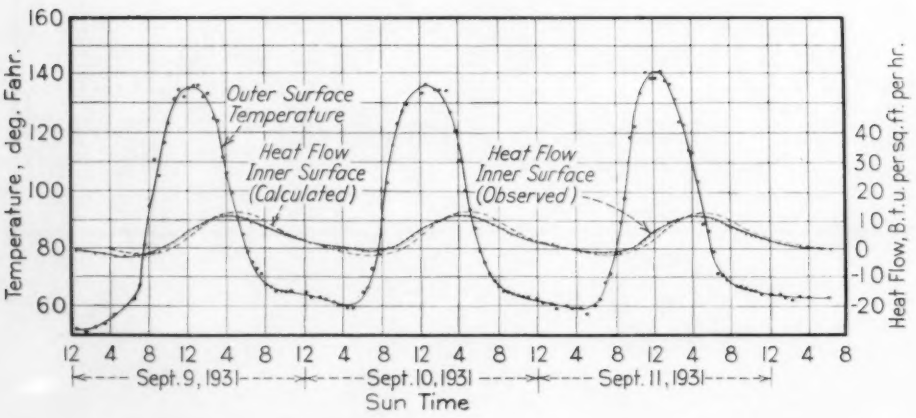

Fig. 10.—Horizontal Roof (Test Panel) A. S. H. V. E. Research Laboratory, Pittsburgh, Pa.

Construction outside to inside: waterproofing, 1-in. cork, 3-in. concrete. Transmittance coefficient $U = 0.242$, heat capacity = 7.58 B.t.u. per sq. ft. per deg. Fahr.

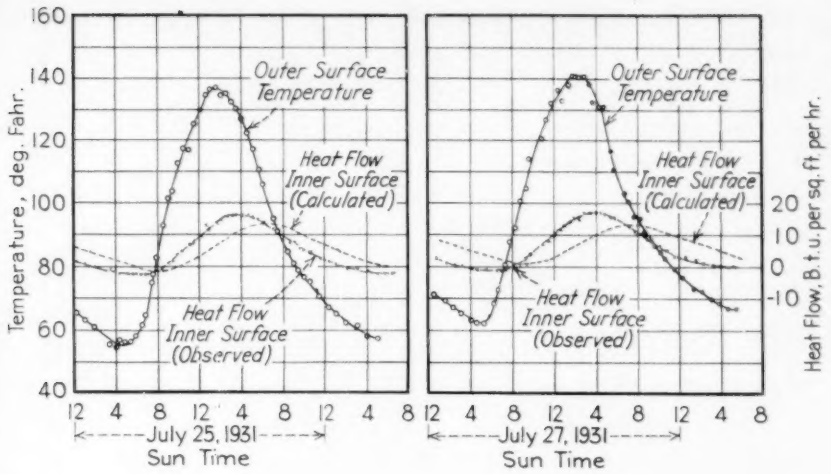
Temperature, deg. Fahr.
Heat Flow, B.t.u. per sq. ft per hr.
Outer Surface Temperature
Heat Flow Inner Surface (Calculated)
Heat Flow Inner Surface (Observed)
July 25, 1931
July 27, 1931
Sun Time

Fig. 11.—Horizontal Roof (Test Panel) A. S. H. V. E. Research Laboratory, Pittsburgh, Pa.

Construction outside to inside: waterproofing, 3-in. concrete, 1-in. cork. Transmittance coefficient $U = 0.242$, heat capacity = 7.58 B.t.u. per sq. ft. per deg. Fahr.

In considering the curves for the three panels in Fig. 12, it should be emphasized that these three panels were constructed so as to give as nearly as possible identical transmittance coefficients as determined under steady state conditions. The differences in the cyclic heat flow shown in Fig. 12, as well as shown generally for Figs. 4 to 13, indicate that heat capacity of the structure may determine to a considerable extent the magnitude and time of the maximum rate of heat flow through the inside surface of a roof or wall.

It follows that the simple linear equation for heat flow under steady state conditions, $Q = UA\ (t_1 - t_2)$, must be replaced by a more complicated differential expression. Such an expression has been developed and shown to apply, at least as accurately as the physical properties of the wall may be predicted. From a knowledge of the instantaneous inside wall surface temperature, the inside air temperature, and the steady state film conductance coefficient of the inside wall surface, the instantaneous rates of heat flow through the inside wall surface may be determined.

The development and proof of the application of the solutions of the problem of the cyclic heat flow from the inside surface of the wall into air-conditioned space, while representing a milestone in the development of the knowledge of the subject, is of little consolation to the designing

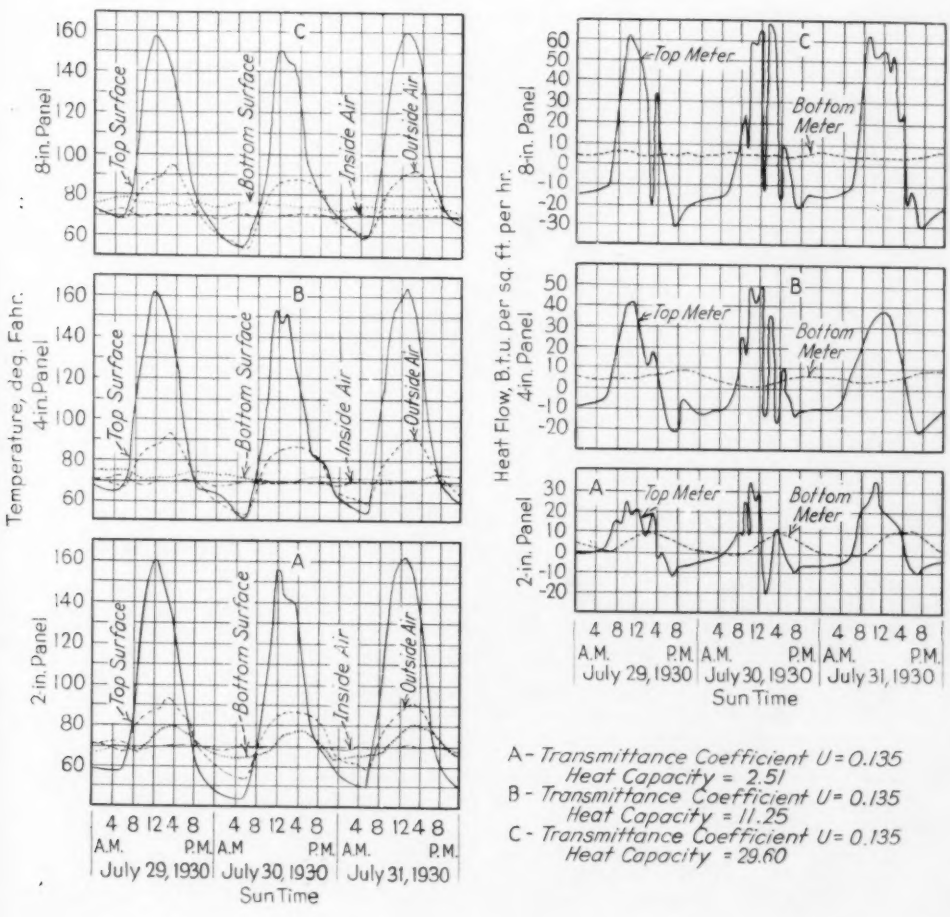

Fig. 12.—Horizontal Roofs (Test Panels) A. S. H. V. E. Research Laboratory, Pittsburgh, Pa.

Construction outside to inside: (*A*) Waterproofing, laminated gasket cork and sheet metal = 2.67 in. (*B*) Waterproofing laminated gasket cork and sheet metal = 4.47 in. (*C*) Waterproofing laminated gasket cork and 3/16-in. iron plate = 8.32 in.

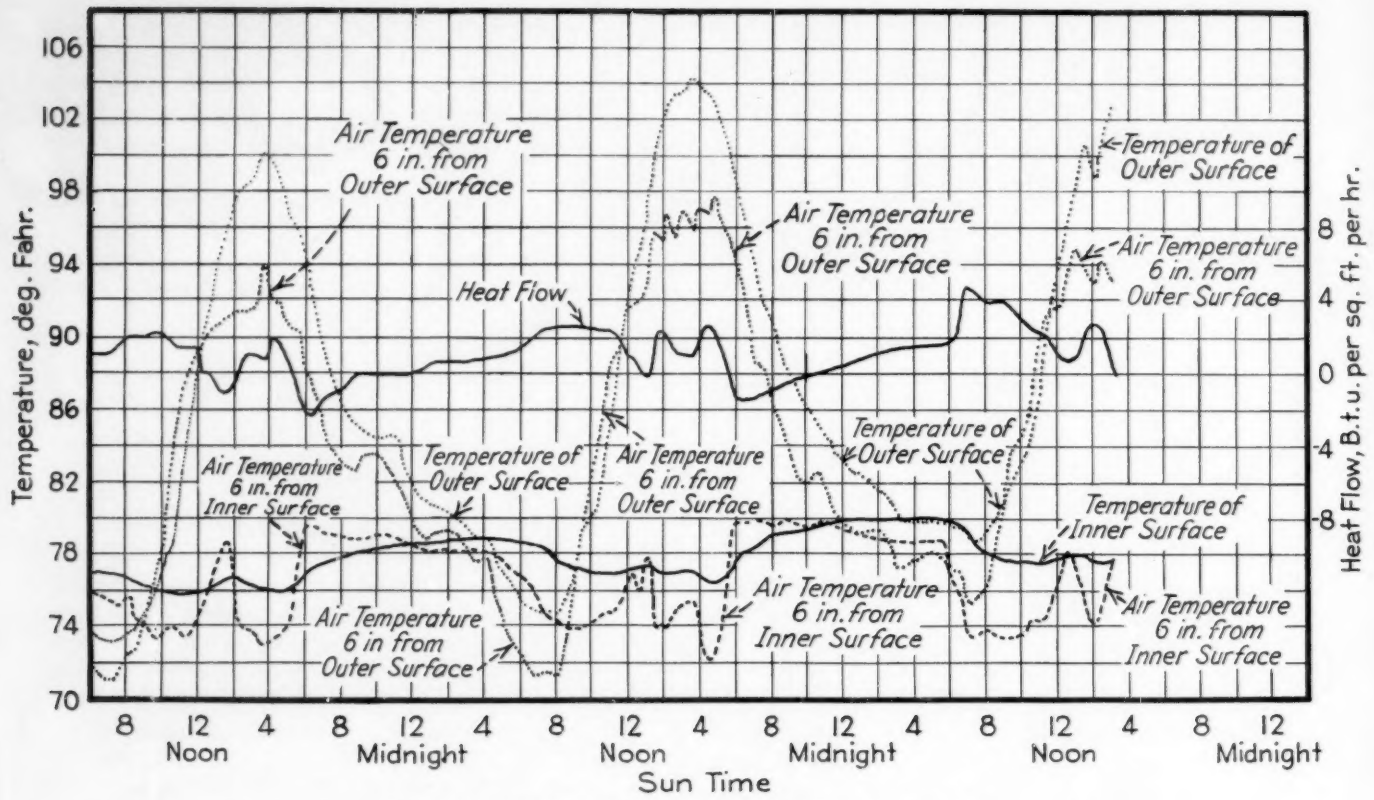
Temperature, deg. Fahr.
Heat Flow, B.t.u. per sq. ft. per hr.
Air Temperature 6 in. from Outer Surface
Heat Flow
Air Temperature 6 in. from Outer Surface
Temperature of Outer Surface
Air Temperature 6 in. from Outer Surface
Air Temperature 6 in. from Inner Surface
Temperature of Outer Surface
Air Temperature 6 in. from Outer Surface
Temperature of Outer Surface
Temperature of Inner Surface
Air Temperature 6 in. from Outer Surface
Air Temperature 6 in. from Inner Surface
Air Temperature 6 in. from Inner Surface
Noon
Midnight
Noon
Midnight
Noon
Midnight
Sun Time

Fig. 13.—South Wall Union Guardian Building, Detroit, Mich.

Construction outside to inside: 9-in. brick, 3¾-in. tile, 5¼-in. air space, 3¾-in. tile, 1¼-in. plaster. Transmittance coefficient $U = 0.17$, heat capacity = 22.0 B.t.u. per sq. ft. per deg. Fahr.

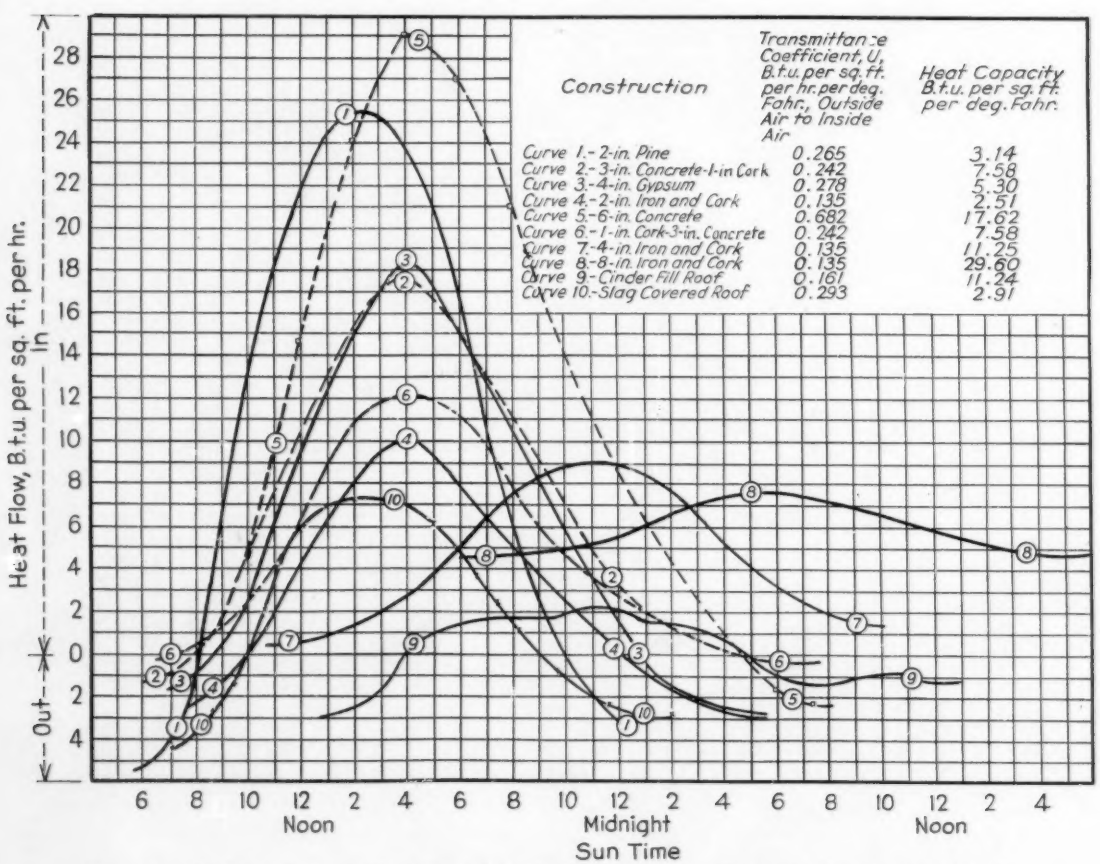
Heat Flow, B.t.u. per sq. ft. per hr.
In
Out
Construction
Transmittance Coefficient, U, B.t.u. per sq. ft. per hr. per deg. Fahr., Outside Air to Inside Air
Heat Capacity B.t.u. per sq. ft. per deg. Fahr.
Curve 1.-2-in. Pine 0.265 3.14
Curve 2.-3-in. Concrete-1-in Cork 0.242 7.58
Curve 3.-4-in. Gypsum 0.278 5.30
Curve 4.-2-in. Iron and Cork 0.135 2.51
Curve 5.-6-in. Concrete 0.682 17.62
Curve 6.-1-in. Cork-3-in. Concrete 0.242 7.58
Curve 7.-4-in. Iron and Cork 0.135 11.25
Curve 8.-8-in. Iron and Cork 0.135 29.60
Curve 9.-Cinder Fill Roof 0.161 11.24
Curve 10.-Slag Covered Roof 0.293 2.91
Noon
Midnight
Noon
Sun Time

Fig. 14.—Relation Between Heat Flow for Hot Summer Days Through Horizontal Roofs Indicated into Cooled and Air-Conditioned Space, and Elapsed Time

engineer: first, because of the laborious effort required; and second, for the reason that the expected cycle of the temperature of the outside surface of the wall must be known. Therefore, the results of the study point to the need of a considerably greater mass of data concerning the magnitudes of the expected changes in the surface temperatures and the rates of heat flow for a number of different types of walls and roofs, with different directions of exposure to sun radiation on days representing typical design conditions. Plans for such a study have been developed and await proper financing.

A possible solution is offered by Figs. 14 and 15. Similar charts containing curves for the heat flow through the inside surface of typical wall and roof constructions should be plotted against a common abscissa of time for each typical exposure, including walls facing the 8 points of the compass, horizontal roofs, and roofs pitched in different directions. These heat flow curves should be for the usual indoor design temperature of approximately 78 F. and for expected typical design outdoor temperatures and sun radiation. Each curve should start with the minimum heat flow rate, resulting from the minimum outside temperature in the morning before sunrise, and continue through the peak, resulting from the maximum outside temperature and sun effect, to the end of the 24-hr. period. This then will allow the designing engineer to plot the expected heat gain for a given wall or roof exposure on a composite chart giving all the sources of heat gain, and finally a total cooling load curve for the given space to be cooled.

In this connection, it should be pointed out that the curves as drawn in Figs. 14 and 15 actually result from work done by various investigators on different days in different years, and for wide variations in locality. Therefore, some of the variations in the magnitudes of the rates of heat flow shown in the figures undoubtedly result from variations in outside temperature and sun intensity. However, since all of these curves were determined for what were considered hot summer days, they do represent approximate variations which might be expected from different types of construction. Such variations in test conditions should not affect the time of maximum heat flow into the cooled space.

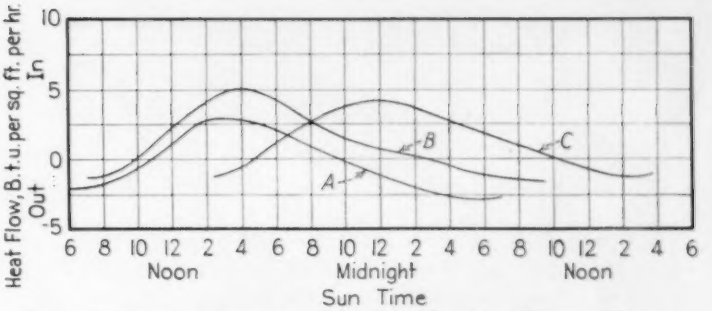

Fig. 15.—Relation Between Heat Flow for Hot Summer Days Through the South Walls Indicated into Cooled and Air-Conditioned Space, and Elapsed Time

Curve *A*—Residence near Birmingham, Mich. Transmittance coefficient $U = 0.06$, heat capacity = 0.85 B.t.u. per sq. ft. per deg. Fahr. Construction: ½ in. insulation board on each side of 2 by 4 in. studs with blanket insulation fill.

Curve *B*—Drake Building. Transmittance coefficient $U = 0.13$, heat capacity = 2.50 B.t.u. per sq. ft. per deg. Fahr. Construction: shingles, sheathing, 2 by 4 in. studs, cabots quilt, insulating lath and plaster.

Curve *C*—Oliver Building. Transmittance coefficient $U = 0.288$, heat capacity = 25.55 B.t.u. per sq. ft. per deg. Fahr. Construction: 13-in. brick.

It will be noted that some of the greatest variations in Figs. 14 and 15 result from purely experimental constructions not typical in the building industry. However, wide variations are indicated even among some of the more typical types of construction; as an example, those between the 2-in. pine roof deck covered with slaters felt and tar or pitch on the one hand, and the cinder-filled roof consisting of 2 thin concrete slabs with an intervening 4 in. of cinders, all covered with slaters felt and tar or pitch.

When complications involving the final solution of this problem are considered, it can easily be seen that research and development in the field of conductivity and heat transfer through building construction may still be pursued for some time in the future.

Welding Handbook—1938

THERE has been recently issued by the American Welding Society the first edition of the "Welding Handbook" which provides up-to-date information in concise form on the subject of welding. The 1200-page volume covers fundamentals of various processes, materials used and testing methods involved and, finally, the applications. There are considerable data also on metal cutting and a number of processes relating to welding and cutting.

Each chapter of the book was prepared by outstanding authorities in the particular field. In addition to the work of the some 90 authors, over 200 other technologists reviewed the publication. A large number of authors and reviewers are affiliated with A.S.T.M.

Following an article on the "Economics of Welding" and two reports giving a "Chart of Welding Processes and Definitions of Terms" and "Welding Symbols and Instructions for Their Use," there are chapters dealing with various processes including types of arc welding (alternating current, automatic, automatic carbon, etc.); then gas welding; atomic hydrogen; followed by fundamentals of resistance and spot welding; thermit welding; oxygen cutting, etc. There are chapters on metal spraying, flame hardening and stress relieving.

Eleven chapters comprise the section on materials and metallurgy covering carbon and low-alloy steels, chromium irons and steels, copper and copper alloys, aluminum and aluminum alloys, etc.

In the section on testing there are chapters on nondestructive tests, fatigue tests, strength tests of resistance welds, inspection of welded pressure vessels and some Navy testing practices.

Almost 400 pages are devoted to welding applications, including ships, pressure vessels, pipe lines, tanks, buildings, bridges, automotive and aircraft products, railroads, etc. Finally there are published critical digests of welding literature.

Copies of this publication in cloth binding can be obtained from the American Welding Society, 29 W. Thirty-ninth St., New York City, at $6 per copy; ($6.50 outside U.S.A.).

Work Under Way; Progress In 1938

(Continued from Page 6)

sets of tests have been made to date after exposures of approximately one year, three years, and six years.

The extent of corrosion has been determined by the same procedure used in the previous tests, namely by measuring the changes in weight of duplicate 9 by 12 in. plate specimens, by visual examination of these plate specimens, and by determining the changes in tensile strength and percentage elongation of tension test specimens.

The subgroup on galvanic and electrolytic corrosion has during the year examined a series of galvanic couples exposed to several different types of atmospheres, the result of which will be made available during 1939.

Electrical-Resistance Alloys

In the field of electrical-heating, electrical-resistance and electric-furnace alloys, Committee B-4 has had an active year and it has a number of important projects confronting it. New tentative standards were issued for temperature resistance constants of sheet materials for shunts and precision resistors (B 114), and for methods of bending of wire (B 113).

The standard accelerated life test for metallic materials for electrical heating (B 76) has been revised and continued as standard, increasing the temperature of tests in order to bring the duration of the test to a reasonable length of time for the improved quality of alloys now available.

The effect of ceramics and cements upon the life of heater element materials is being studied and a study is being made to correlate the bend test method for wire with other test methods.

Equipment has been developed for making bend tests at high temperatures on bars for furnace structures. Tests are being made at 1800 F. A warpage test is being developed to determine the tendency of these materials to warp when subjected to wide variations in temperature. A study of sizes and sections of specimens is being made, in connection with the warpage test.

Work is under way to modify the test for flexivity of thermoflex (thermostatic metals) (B 106) to permit either point or knife-edge supports for the test specimen and to provide a correction factor for cross bending when knife edges are used. Also, to permit thinner materials to be tested. A method of test for effective modulus of elasticity is being developed. A method of test for hardness is under consideration.

Methods of test for materials for radio tubes and incandescent lamps are being developed including a test for brittleness of tungsten wire, and tests for cathode sleeves and tubing, plated material, and copper clad nickel-iron alloy used for sealing in glass.

The subcommittee on the effect of furnace atmosphere on furnace resistors has made many tests on alloys in different atmospheres at various temperatures in electric furnaces and has studied the results. A standard method of test for determining the effect of furnace atmospheres upon the life of furnace resistors is considered desirable to permit comparisons of resistance under various conditions. A preliminary draft of such a test has been prepared and substantial progress has been made in obtaining the information necessary to complete the method.

Copper Alloys

Committee B-5 on Copper and Copper Alloys completed a new, more comprehensive tentative standard (B 36) covering brass sheet and strip to replace the old standard (B 36 – 33) on sheet high brass, containing additional physical properties and covering more alloys than were included in the previous standard. The specifications for wrought phosphor bronze bearings and expansion plates for bridges and structures (B 100 – 35 T) were completely revised and reissued under the title "rolled copper-alloy bearing and expansion plates for bridge and other structural uses (B 100 – 38 T)." The tentative specifications for bronze castings for turntables and movable bridges (B 22) and for copper and copper-alloy seamless condenser tubes and ferrule stock (B 111) were continued as tentative. The specifications for aluminum-bronze castings (B 59 – 36) were revised while the tentative specifications for bronze castings in the rough for locomotive wearing parts (B 66) and for car and tender journal bearings, lined (B 67) were advanced to standard.

The committee has prepared a revision of the standard on copper water tube (B 88) which it is believed will be adopted during the coming year.

Consideration is now being given to the preparation of specification requirements covering leaded brass sheet, leaded and non-leaded nickel silver sheet, leaded phosphor bronze sheet, beryllium copper sheet, various copper alloy wire and rod materials, a comprehensive specification on copper-base alloy forging rods to replace the present standard on brass forging rod (B 15) and a general specification on miscellaneous brass tubing. It is expected that these specifications will be presented in tentative form for consideration by the Society at the annual meeting.

The committee is also sponsoring a paper on "Service and Life of Non-Ferrous Tubular Material" by H. F. Dixon to be presented at the annual meeting. A subcommittee is now actively working on a compilation of copper and brass terms used in the copper industry. It is hoped that this work will be completed by June to permit publication of this work either in the form of a special paper sponsored by the committee or as an A.S.T.M. designation. The committee is also sponsoring a paper by Sam Tour on "Copper and Copper Alloy Castings" to be published as an appendix to the 1939 B-5 report.

Die Castings

The specifications for zinc-base alloy die-castings (B 86) were revised during the year on the recommendation of Committee B-6 to include specification requirements for Alloy No. XXV, an alloy having physical properties intermediate between those of Alloys Nos. XXI and XXIII. Minor changes were made in the specifications to indicate more definitely the number of test specimens required.

A special group has investigated the effect of impurities on aluminum-base alloy die-castings. Based upon their studies

this special committee has recommended that in the specifications B 85 the maximum permissible zinc content for Alloy No. VII be increased from 0.8 to 1.0 per cent and the maximum zinc content for Alloy No. XII, from 1.5 to 1.75 per cent. It is also recommended that the maximum tin content be increased from 0.1 to 0.25 per cent.

The original exposure tests in its corrosion testing program have now been under way for ten years and the committee plans accordingly to call in the ten-year exposure specimens early this year. Arrangements for the testing of these specimens are now under way. Likewise, flat tension test bars of special purity aluminum alloys have been withdrawn from the outdoor test racks at New York, Sandy Hook, and Altoona after four years exposure. Microscopic examination of the corrosion products will be made.

A second producer has supplied test specimens of the five lead and tin-base alloys which are being studied to determine their physical properties. These will be distributed in the near future to those committee members who are cooperating in these tests. Preliminary tests on the first set of specimens have been completed and are now being analyzed prior to reporting the results to Committee B-6. The creep tests are also under way.

The atmospheric exposure tests of the three zinc-base and the four magnesium-base alloys which are included in the expansion of the committee's corrosion testing program, have been started. On the former alloys, the chemical analyses, initial physical properties, and the effect of the steam chest test have been determined. Other tests will be made during the coming year.

Light Metals and Alloys

At recent meetings of Committee B-7, consideration has been given to revisions in the existing specifications for aluminum ingots for remelting (B 24) and aluminum for use in the manufacture of iron and steel (B 37). It is hoped that these modifications, as well as a new specification for aluminum-base alloy ingot for die castings, will be ready for committee approval at the 1939 spring meeting. During the year the committee developed a new tentative test for dielectric strength of anodized aluminum which is based on data published in the 1937 report covering methods of testing oxide coatings on aluminum. One of the principal uses of this method at the present time is to obtain the approximate measure of the thickness of anodic coatings. Revisions were made in the five tentative specifications covering various products of magnesium-base alloy composition, and four aluminum-base specifications were likewise modified.

In connection with the program on the testing of light metals, a summary of the effect of foundry variables on mechanical properties of sand-cast tension test specimens was presented earlier in the year in connection with the annual report of Committee B-7. Arrangements have also been made to cooperate with Committee E-1 in its program on the effect of speed of testing. The effect of impurity variation on the properties of aluminum-base alloys, started several years ago, is progressing and a preliminary report is expected for the spring meeting. A study of methods of testing anodic coatings has also been continued during the year and it is hoped that a tentative test method for abrasion resistance will be ready shortly.

The committee is planning to revise the report issued several years ago entitled "Service Characteristics of the Light Metals and Their Alloys" in order to bring this publication up to date in the light of present commercial practice.

Chemical Analysis of Metals; Spectrographic Analysis

During the past year, Committee E-3 on Chemical Analysis of Metals revised the methods for chemical analysis of ferrosilicon, ferromanganese, ferrochromium, ferrovanadium, ferrotungsten and ferromolybdenum. These methods were issued as a new tentative standard E 31 - 38 T, replacing immediately the previous standard A 104, and methods for the sampling of ferromanganese, silicomanganese, ferrophosphorus, zirconium alloy, spiegeleisen, ferrochromium, silicon metal, and calcium-silicon alloy were also completely revised. These new procedures are being published as a supplement to the present volume on "Chemical Analyses of Metals." Work is being continued on an extensive program involving revision of the present standardized methods for the analysis of non-ferrous alloys. It is hoped that preliminary reports of the subcommittee in charge can be made early in the year, and that completed methods can be published in 1939.

Committee E-2 on Spectographic Analysis is giving further consideration to a method for spectrochemical determination of aluminum in zinc coating of galvanized iron and steel. The subcommittee on standards and pure materials will cooperate in the preparation of standard samples, since there is a need for this work. High purity copper is now available in moderate amounts and it is expected that high purity silicon will soon be available. The work of Subcommittee III on Quantitative Methods and Applications is being completely reorganized. Various groups will devote their efforts to work on specific metals. The committee is encouraging the development of technical papers in its field, some of which may be prepared for presentation at the 1939 annual meeting in Atlantic City.

Metallography

Work extending over a considerable period of time on the part of Committee E-4 on Metallography resulted in the new tentative grain size chart for classification of steels (E 19). The chart gives a series of grain outlines representing the grain size which may be encountered in the austenite of various steels at different temperatures in the austenite range. This is essentially a tentative revision of the existing standard E 19.

The committee fostered presentation during the year of three technical papers on subjects of interest in the committee's work.

The committee also developed a source of supply for polishing cloth of outstanding quality and sponsored a quantity purchase of this which those desirous could in turn obtain. The committee is studying three existing standards covering preparation of micrographs of metals (E 2), recommended practice of metallographic testing (E 3), and definitions of terms relating to metallography (E 7). It is anticipated that the latter will undergo extensive revision and amplification. A technical paper on the use of color in

metallographic work is being developed. Another project involves the drafting of recommended practices for X-ray diffraction and dilatometric work.

Radiography

Committee E-7 on Radiography, organized formally in February, 1938, now has a membership of 46 representing very completely the technical, producing, and consuming interests that touch the field of radiography. There are six subcommittees.

At the annual meeting a technical program was sponsored. Of the four papers, three were the first reports in a long range research plan that it is expected will take several years to complete. Radiography, in spite of its sixteen years of use, is still relatively undeveloped as a method of non-destructive testing. The research program, perhaps the most comprehensive fundamental series of studies that has been undertaken in the field, has as its immediate objective the depiction of unsoundness conditions in metals with the clarity and reliability of a good photograph.

Subcommittee I, Radiography of Castings, has started work on more immediately practical studies that look toward the most profitable utilization of radiography in the casting industry. There will be full cooperation with foundry interests.

Subcommittee III, Radiography of Weldments, is working out radiographic standards that, when completed, will be offered for approval to the Society.

It is hoped to coordinate, through Committee E-7, the best technical research in its field of testing and to offer technical programs from time to time as good papers become available.

Cement

During the year Committee C-1 on Cement made considerable progress on a number of problems before it. The specifications for portland cement (C 9) were revised to agree with the high-early-strength portland cement specifications (C 74) on the question of additions. The last-named specifications were revised by deleting the fineness test requirement. Two rapid methods for determining magnesia in cement were advanced to standard as parts of the methods for sampling and testing (C 77). The methods of chemical analysis of portland cement were amplified by the addition of tentative methods for determining manganic, potassium and sodium oxides. The method for the turbidimetric fineness test of portland cement (C 115) was revised.

The tentative specifications for masonry cement (C 91) were revised, two important changes being made involving a marked increase in the strength requirements, and, second, a requirement covering the change in workability of mortars produced by the removal of some of the mixing water. A revised text of proposed tentative specifications and methods of test for blended cements was distributed to Committee C-1 members to promote discussion and accumulation of additional data.

There was undertaken a study of a quick method for determining phosphorus pentoxide in portland cement. The extensive study, by a large number of laboratories, of methods for determining free lime in portland cement was completed and published. (ASTM BULLETIN, October, 1938).

Fourteen laboratories completed a compressive strength study of pebble mortars ("baby concrete") in the form of 2-in. cubes. The results were reported in the 1938 *Proceedings* and additional work was planned along this line. A preliminary study of "bleeding" was made.

Committee C-1 completed tests, performed in accordance with the provisions of the high-early-strength portland cement specifications (C 74) to determine whether a certain material might be considered as non-harmful when used as an addition subsequent to calcination in the manufacture of such cements.

The Cement Reference Laboratory made a substantial start on its sixth tour of inspection among cement laboratories. A number of laboratories not previously visited were included among those requesting inspection. A second comparative test sample was distributed by the Reference Laboratory to more than 150 laboratories and the results have been assembled for reporting. The study included physical tests and chemical determinations.

The extensive series of studies of variables in the proposed autoclave test for cements was completed. The results obtained by a number of laboratories, using 35 cements, were assembled and formed a lengthy report on the subject, appearing in the 1938 *Proceedings*. A proposed method for the autoclave test of portland cement was approved by Committee C-1 for future recommendation to the Society as a tentative test method. This is published as information in the 1938 Report of the committee in Part I of the 1938 *Proceedings* and also in the 1938 special compilation of ASTM Standards on Cement.

Lime

Certain actions were taken during the year on the recommendation of Committee C-7 on Lime, one involving the deletion of the soundness test from the tentative methods of physical test for limestone, quicklime and hydrated lime (C 110). The committee also developed two specifications for quicklime for use in paper manufacture and a method for determination of available lime in high-calcium quicklime and hydrated lime by the rapid sugar test, these three items being published in the final report of the committee for information and to stimulate comment. After consideration extending over several years, the committee also recommended new tentative specifications for hydraulic hydrated lime for structural purposes (C 141).

Refractories

With changes in manufacturing technique and general improvements in quality of refractories, it becomes necessary from time to time to revise or change completely the methods of testing. One of the most important tests on refractory materials is the so-called hot-load test which measures the resistance of the refractory to deformation or failure at high temperatures under load. Committee C-8 on Refractories has been working for several years on changes in the method of testing, and a new procedure is ready to be presented to the Society for adoption as tentative standard.

The committee, likewise, after several years' work is ready to present a new set of tests on refractory insulation, including block insulation.

A new method of testing size, warpage, and bulk specific gravity of refractory brick (C 134) was issued as a tentative

standard; also a method (C 135) for determining true specific gravity of burned refractory materials.

The committee recently completed an industrial survey entitled "Industrial Survey of Conditions Surrounding Refractory Service in Continuous Plate and Window Glass Furnaces." The committee is also about to release an industrial survey on refractories in lime-burning kilns.

Concrete and Concrete Aggregates

Four new tentative methods of test were developed during the year by Committee C-9 on Concrete and Concrete Aggregates. The first for determination of yield of concrete (C 138) establishes a standardized procedure in a field where several different methods were used. The test for soundness of aggregate by freezing and thawing (C 137) will stimulate investigation of a very important factor in the durability of concrete and fills a marked need in testing procedure. The third, a method of testing for clay lumps in aggregate (C 142) was submitted at the meeting of Committee E-10 in August. The fourth, a method of test for sieve analysis of fine and coarse aggregates, developed in cooperation with Committee D-4, establishes in one method requirements previously covered in four existing standards which were withdrawn.

In light of experience, revisions were made in three other methods of test, namely, for abrasion of coarse aggregate by use of the Los Angeles machine (C 131) (in cooperation with Committee D-4); for unit weight of aggregate for concrete (C 29); and for structural strength of fine aggregate (C 87).

Two technical papers covering subjects of important interest to Committee C-9 were included as appendices to its 1938 report. The first on "Stress-Strain Characteristics of Mortars and Concretes" is by H. J. Gilkey and Glenn Murphy and the second on "Factors Affecting the Testing of Concrete Aggregate Durability" is by Charles E. Wuerpel.

Committee C-9 plans to present five new methods of test during 1939. These methods are: for determination of the volume of air entrained in concrete; for making freezing-and-thawing tests of concrete and mortar; for determination of organic matter in fine aggregate; for determination of volume change in concrete; and for measuring the efficiency of curing agents for portland-cement concrete.

Two technical papers are in process of preparation. One, covering observations on the diffusion of water vapor through concrete, was originally contemplated for 1938 but will not be ready until this year. The other paper deals with the evaluation of test data.

Gypsum; Concrete Pipe

Several important actions were taken by Committee C-11 on Gypsum during the year. Changes were drafted in the specifications for Keene's cement (C 61 – 30) involving the use of a 150-g. modified Vicat needle in the consistency test and a corresponding minimum tensile requirement change from 450 to 400 lb. per sq. in.

A tentative change in the requirements for gypsum plaster will eventually permit the use of the new type of set-stabilized plasters now on the market, the setting time of which are not influenced greatly by job conditions. The requirement on time of setting is to be reduced from 8 hr. to 2 hr.

Several tentative changes were drafted in the methods of testing gypsum and gypsum products (C 26), one of these involving the incorporation of the ammonium acetate method of determining the sand content of set gypsum plaster.

Committee C-13 on Concrete Pipe has been considering for some time necessary revisions in the specifications for concrete irrigation pipe (C 118). Comments and criticisms were received from a number of engineers concerned with irrigation and the extensive changes made in the specifications were based on their recommendations.

Mortars

Committee C-12 on Mortars for Unit Masonry was reorganized in November, 1937. Standing subcommittees on methods of test, specifications for mortars, and specifications for sand for mortars were established, as well as working subcommittees on workability and on volume change of mortar. The first-named group drafted a report which was accepted by the committee and published in the October ASTM BULLETIN under the title, "A Preliminary Consideration of some Proposed Methods of Sampling and Testing Mortars for Unit Masonry." The Subcommittee on Specifications prepared and circulated a draft of "Proposed Specifications for Mortars for Unit Masonry." The discussion and correspondence elicited by this draft indicated the desirability of two further actions preliminary to the acceptance by the committee of a specification. The producer members of C-12 have been asked to report the results of tests on their own materials and it is intended to draft and circulate a manual or primer on the application and interpretation of tests for mortar.

The Subcommittee on Sand for Mortar submitted a report which included a proposed specification. This report will appear in a forthcoming issue of the BULLETIN.

The Working Subcommittee on Workability is considering possible substitutes for the flow table. Pending development and acceptance of a new test, the development of means for calibrating the flow table has been requested.

Consideration of the autoclave test for expansion and soundness and the Rogers and Blaine test for shrinkage has been assigned to a Working Subcommittee on Volume Change in Mortars.

Manufactured Masonry Units

During the year the standard specifications for building brick (made from clay or shale) (C 62 – 30) were withdrawn, leaving the tentative specifications C 62 – 37T as the only A.S.T.M. standard for this product. The subcommittee has continued its studies in an effort to determine methods by which bricks which are likely to be durable in service can be distinguished readily from those which are not resistant to weathering. Postponement of the adoption as standard of the tentative specifications was approved, for a limited time, pending the completion of a program of research at Alfred University.

The new tentative specifications for concrete masonry units for use in construction of catch basins and manholes (C 139) were approved by the Society. The committee recently reviewed and approved proposed specifications for solid load-bearing concrete masonry blocks.

The standard specifications for sand-lime building brick (C 73 – 37) were withdrawn, replaced by new Tentative Specifications (C 73 – 38T). At its November 1 meeting, the committee approved the adoption as standard of this tentative specification.

A comprehensive investigation of paving brick is being carried out by the Ohio State Highway Commission and the U. S. Bureau of Public Roads. The investigation will include a comparison of the performance of paving brick in experimental roads with the results of laboratory tests.

The subcommittee on glazed brick and tile is planning an investigation of glazed building units, which will be carried out by Rutgers University under the direction of Prof. J. R. Kauffman. Specimens of commercial glazed brick, tile and architectural terra cotta will be subjected to the tests described in the tentative specifications C 126 – 37 T. It is planned, also, to obtain data on the relation between the properties determined in these tests and performance in service.

In the new tentative specifications for structural clay load-bearing wall tile (C 34 – 38 T), some of the shape factors which, in former standards, had been controlled indirectly by limitations on weight, are specified directly. No limitations on weight are included. The geometrical properties specified include minimum thicknesses for shells and webs, dimensional tolerances on scores, minimum number of cells, through tile and wall and, for side construction tile, the ratio of maximum cell width to bearing shell thickness. The tentative revisions of the standards for non-load bearing tile (C 56 – 36) and for floor tile (C 57 – 36) are for the purpose of replacing requirements on weight with limitations on shape.

A program of tests of the effect of slenderness on the apparent strengths of brick masonry prisms was completed during the year. The results were reported as a part of the annual report of the committee in a paper by Prof. W. J. Krefeld, entitled, "Effect of Shape of Specimens on the Apparent Compressive Strength of Brick Masonry."

The results of an investigation of the effect of differences in technique of making laboratory freezing-and-thawing tests on the disintegration of clay building brick are described in a paper by J. W. McBurney, entitled, "The Freezing-and-Thawing Test for Building Brick."

The working committee on modular sizes for masonry units (Frederick Heath, Jr., chairman), prepared a list of sizes of masonry units based on the use of a 4-in. module. Copies of this list have been distributed to members of the committee.

Glass and Glass Products

Considerable progress has been made in various fields of endeavor by Committee C-14 on Glass and Glass Products. There are two projects involving chemical analysis: first, the formulation of a method for analysis of glass sand; second, methods of chemical analysis of glass. A proposed draft of the first method has been developed. A rather extensive cooperative program on chemical properties is being initiated somewhat similar to that carried out by the Glass Division of the American Ceramic Society but covering a number of other points.

Progress has been made in the work on mechanical strength and thermal resistance, drafts of methods for these properties having been made. The subgroup on glass construction block and tile is concentrating on glass blocks and is following closely a number of research projects which are under way in the industry. While the group's considerations are limited to the physical and other characteristics of individual blocks, it is felt that the complete story of the material and how it is used must be developed before specification requirements can be standardized. The work under way is extremely ramified as mentioned briefly in the committee's 1938 report.

Paints, Varnish, and Related Products

The past year was a productive one for Committee D-1 on Paint, Varnish, Lacquer, and Related Products. Seven new tentative standards were developed covering aluminum pigment paste for paint (D 474), c.p. para red toner (D 475), c.p. zinc yellow (zinc chromate) (D 478), titanium dioxide pigments (D 476), zinc sulfide pigments (D 477), methods of sampling and testing aluminum powder and aluminum paste (D 480) (concurrently the standard D 306 was withdrawn), and method of test for reactivity of paint liquids (D 479).

Four existing tentative specifications were adopted as standard covering basic sulfate white lead and blue lead (D 82 and D 405), wood to be used as panels in weathering tests (D 358), and methods of testing oleo-resinous varnishes (D 154). Numerous revisions of standards and tentative standards were accomplished.

There are a number of active projects under way, one of which includes the development of a Symposium on Testing to be held at the 1939 annual meeting in Atlantic City. A questionnaire on accelerated testing, to be published in the BULLETIN, is nearing completion. This is designed to secure information concerning accelerated testing methods now in use, and the various types of film breakdown that are considered most significant by operators.

Work on standardizing a method for determining the consistency of enamel-type paints is under way involving consideration of several instruments now in use. The committee plans to consider methods for determining certain turpentine adulterants.

Proposed revisions in the specifications for orange shellac (D 237) and shellac varnish (D 359) are being studied and modifications of the tentative requirements for titanium dioxide pigments and zinc sulfide pigments have been considered.

In the work on physical properties of materials, the subcommittee is developing a test method and set of definitions for gloss. Present plans include the measurement and recording of color changes in certain paint samples that are being submitted to laboratory test as part of the program in connection with accelerated tests for color changes of house paints.

A new subcommittee on painting of structural iron and steel is developing its plans which will include ultimately a series of tests to note the relative advantages or disadvantages of applying various chemical and mechanical pre-treatments to steel.

Petroleum Products and Lubricants

Accomplishments of Committee D-2 on Petroleum Products and Lubricants in 1938 include the development of four

new test methods and one specification—the tests cover acid heat of gasoline (D 481), ash content of petroleum oils (D 482), unsulfonated residue of plant spray oils (D 483), and the specifications, Stoddard solvent (D 484). Five of the committee's tentative standards were revised and changes were recommended in six of the existing standards; in two of them the test for distillation of gasoline, naphtha, kerosine, and similar petroleum products (D 86) and testing gas oils (D 158), the changes being adopted immediately.

The committee will give further attention to two methods which have been published as information, one for dropping point of grease and the other for determination of ignition quality of Diesel fuels. Modification of the grease worker in penetration of lubricating grease and petrolatum (D 217), revision of method for determining water in grease (D 128), and study of methods for determining consistency of soft lubricating greases are other projects.

In the work on viscosity, additional instruments for determination of kinematic viscosity will be studied; also the applicability of the Dean-Davis viscosity index system to the A.S.T.M. viscosity-temperature chart (D 341). Work on sampling and gaging involves the preparation of a report on gaging methods. Other testing procedures being considered will cover determination of aniline point, smoke point of kerosine, and gum stability of gasoline. A group working on carbon residue plans to study the Ramsbottom coke test and the section on lubricants is considering the relation between oxidation tests on lubricating oils and service performance.

Gaseous Fuels

Committee D-3 on Gaseous Fuels has continued developmental work on definitions and methods. Drafts of tentative methods are being prepared for the determination of total sulfur in gaseous fuels by the referees' apparatus; for the sampling of manufactured, natural, and liquefied petroleum gases; for the determination of heat of combustion of gases; and for the measurement of gases for testing purposes.

The preparation of tentative definitions for relative humidity, absolute humidity, and dew point of gases is nearing completion.

Comparative tests of specific gravity apparatus, both indicating and recording, have been undertaken in cooperation with the National Bureau of Standards; also in cooperation with the same institution the subcommittee on complete chemical analysis has obtained data from representative laboratories pertaining to the listing and classification of types of apparatus according to physical and chemical principles involved. A plan of investigation of the principal types of apparatus has been prepared and a special container has been constructed for the transportation of standard gas samples for comparative analysis in different laboratories. Two types of standard gas samples have been selected for initial studies. These are carburetted water gas of 500 to 600 B.t.u. per cubic foot heating value and natural gas of 1100 to 1150 B.t.u. per cubic foot heating value.

Road and Paving Materials

The activities of Committee D-4 on Road and Paving Materials were marked by intensive work involving consolidation of many of the specifications and tests in the charge of the committee. At the annual meeting there were approved seven new tentative standards which replaced sixteen existing standards. The new items cover test for sieve analysis of aggregates (C 136) and specifications for crushed stone and crushed slag for: waterbound base and surface courses (D 489 and D 488), bituminous macadam base and surface courses (D 192 and D 487), and bituminous concrete base and surface courses (D 485 and D 486). In addition, eight former tentative specifications covering various types of tar were replaced by a single specification. This covers low, medium, heavy and extra heavy consistency tar and cutback tar.

An important achievement of the committee was the completion of tentative specifications giving for the first time standardized requirements for asphalt plank (D 517). Desirable modifications were approved in the test for abrasion of coarse aggregate by use of the Los Angeles machine (C 131) and tentative revisions were made in the method of test for ductility of bituminous materials (D 113).

Interesting information developed by the Washington State Highway Dept. concerning the effect of variables on the float test is being studied. A very comprehensive program of cooperative work on the emulsion test has been developed with the aim of securing information on a number of points. Revisions are being developed in the specifications for emulsified asphalts (D 397, D 398, D 399 and D 401) and the committee would welcome, particularly from consuming interests, suggestions of any points which should be considered.

Coal and Coke

There are several active developments under way in the work of Committee D-5 on Coal and Coke. One of these involves the studying of methods for determining cubic foot weight of crushed bituminous coal in order to develop a method giving results agreeing with those occurring in by-product coke ovens. It is thought that a modification of the present standard method D 311 by which the sample is packed under specified conditions of shaking or dropping will give values agreeing better with coke oven conditions. Bulk density in ovens is important for some coals in relation to the expansion of the charge during coking.

Much information is being accumulated on the grindability of various coals as determined by the two existing methods, ball-mill (D 408) and the Hardgrove-machine (D 409). Likewise, data are being gathered on how well the tests for coal friability (D 440 and D 441) measure handling properties of coal. There is particular activity on coal sampling and on plasticity and swelling of coal. A method of sampling coals classed according to ash content (D 492) was issued as tentative during the year and consideration is being given to schemes for sampling run-of-mine and for sized coal under 6 in. in size. For run-of-mine coal the considerations involve procedures for use at the mine and also at points of delivery.

The group concerned with plasticity and swelling distributed a series of different coals to various cooperating laboratories to be tested by different methods under consideration. The first series of such tests have been completed and the data are being compiled and studied. All methods now in use are necessarily empirical in nature and require close standardization to be of value.

A special section of the subcommittee has been formed to study swelling of coals when fired on grates since this is a different problem from expansion during coking. The work on ignitability will go forward. Studies of published papers

have been made and experimental investigations are being considered. A definition of the term "ignitability" is also being prepared.

Waterproofing and Roofing Materials

One of the accomplishments of Committee D-8 on Bituminous Waterproofing and Roofing Materials was the issuance of a new tentative specification for asphalt mastic for use in waterproofing (D 491). This covers the material produced by mixing of all mineral aggregate constituents, mineral filler and the asphalt cement on the job. In order to bring up to date a number of tentative standards, revisions were approved during the past year and one item, covering burlap saturated with bituminous substance for use in waterproofing, was withdrawn, since use of this material has been discontinued.

The committee is preparing felts containing mixtures of various types of rayon fibers for cooperative tests using an extension of the present method of analysis of roofing felt (D 272) for differentiating between types of rayon, that is, viscose, acetate, or cuprammonium, from the usual components of felt. The work in developing the volume correction tables for asphaltic products is to be continued with computation of tables for two other groups not now covered, namely, Group 00 and Group 000.

The committee contemplates revisions of a number of existing standards covering asphalt mastic (D 169), bituminous grout for use in waterproofing above ground level (D 170), bituminous grout for use in waterproofing below ground level (D 171), acid-resisting asphalt mastic (D 223), and others. These studies are continuing during the current year, the standards having been reverted to the status of tentative, effective in 1939.

Electrical Insulating Materials

New methods of test for determining the resistance of molded and laminated phenolic materials to arcing (D 495) and acetone extraction of phenolic molded or laminated products (D 494) were issued as tentative as a result of the work of Committee D-9 on Electrical Insulating Materials. The committee also made extensive improvements in numerous other test methods and specifications and completely revised the tentative methods of testing sheet, tape and molded insulating materials for dielectric strength (D 149) so as to make them general test methods to which the various material standards may refer.

The development of methods of test for dielectric strength, dielectric constant and insulation resistance of shellac and a method of measuring the impregnating property of varnish are being continued. A test for resistance of varnish to acid and salt water is being investigated.

A new procedure for measuring shrinkage of molded parts from mold dimensions and specifications for a standard mold for compression molded ½ by ½ by 5-in. test bars are anticipated during 1939. Other projects that are in active progress are the conditioning of thermoplastic materials and the round-robin tests for determining tracking or burning due to low-voltage currents in molded insulating materials.

In the work on plates, tubes and rods, an extensive investigation of conditioning specimens for test is approaching completion and standards will soon be established. Studies are being made with soft materials to determine the limiting value at which the large diameter ball of the Rockwell hardness tester should be used to insure proper accuracy; also to compare Rockwell hardness of hot specimens with actual punching quality. The program of tests on laminated phenolic plates differing in conditions of cure, resin content, and moisture content to determine which tests will detect the variations has been completed on the paper-base plates and similar tests are planned on cloth-base plates.

A revised program has been outlined on the development of a suitable sludge accumulation test for insulating oils and an oxidation test under pressure is also being investigated. A new section has been created which is studying methods of measuring the evaporation of insulating oils. A revised dielectric strength test method is being prepared and will be presented during the coming year. The round-robin tests for power factor, dielectric constant, and resistivity are being continued. Since the studies of insulating oils have now extended to cable oils and also non-petroleum products, the entire work of this subcommittee is to be reviewed.

The methods of testing porcelain for porosity by means of dye penetration and tests for power factor and dielectric constant of steatite materials are being studied. The work on glass insulators is being continued.

The methods of testing electrical insulating materials for power factor now include work on liquid and solid insulating materials and tests at ultra-high frequencies.

A modified form of penetrometer for measuring oil penetration in papers has been developed and studies are being made to develop a standard test procedure. The investigation of the dial micrometer and the improved form of machinist's micrometer, having a spring to control the pressure, is being continued.

A method for determining the effect of humidity upon the dielectric strength of varnished cloth is being prepared. A study of elongation requirements and the effect of creasing upon dielectric strength is being made with a view to eliminating the present creasing requirements in tape specifications or substituting a more satisfactory test procedure. The differences between the A.S.T.M. specifications for varnished-cloth tape and the newly published N.E.M.A. specifications are to be reviewed, possibly by a joint committee of the two societies. The method of testing varnished tubing is being revised to include saturated sleeving.

Color photographic plates are being prepared for use in the classification of mica.

A standard conditioning chamber which will eliminate some of the variables now existing in the unusually wide choice of equipments and which will permit a higher degree of conformance between testing laboratories is being devised. A definition of "room temperature" is to be submitted during the coming year.

Reports on Significance of Tests (dielectric strength, resistivity, power factor, etc.) have been published during the past two years and the committee is now drafting material on mechanical tests and general applications.

Rubber Products

Standardization and research in the field of rubber products was carried forward intensively in 1938 by Committee D-11. New tentative standards cover methods for testing flat rubber belting (D 378) and test for resistance to light checking and cracking of rubber compounds (D 518). Con-

current with the approval of D 378 which provides in a single standard test procedures applicable to all flat types of rubber belting, the existing standard was withdrawn. The committee also effected a number of desirable revisions in several tentative and standard specifications and tests.

The change in the methods of testing rubber hose (D 380) makes the methods applicable for all types and constructions of rubber hose. One of the changes in the methods of testing rubber-insulated wire and cable (D 470) was the addition of a test for ozone resistance. Two tentative standards in quite general use covering tests for friction tape (D 69) and rubber-insulating tape (D 119) were adopted as standard on the recommendation of Committee D-11, some changes being made prior to adoption in the latter item.

Work on chemical analysis is quite active. An extensive cooperative test program has been carried out on precise methods of determination for copper and manganese; procedures for sulfur and carbon black are also being investigated.

It is planned to develop a method of test for abrasion of rubber-covered electrical conductors. The subcommittee working on life tests is analyzing data collected in the cooperative accelerated aging program using the method for air pressure heat test of vulcanized rubber (D 454) since results may indicate the desirability of certain changes to improve uniformity of results obtained in different laboratories. Consideration will be given to the desirability of including in the method of testing rubber compounds for resistance to light checking and cracking (D 518) dynamic light tests as well as the static tests now specified.

The committee plans to expand the present method of test for flexing (D 430) to include additional types of equipment such as the Goodrich flexometer and the St. Joseph Lead Co. flexometer. Since new equipment is constantly being developed, it is felt desirable to continue this method as tentative so that important additions can be made easily from time to time.

Tests of liquid rubber products are being carried out involving determination of total solids and viscosity of rubber cements. A review of latex procedures as adopted by the Crude Rubber Committee of the American Chemical Society and the investigation of strength tests and procedures to determine drying time of cements are other projects.

The new committee on sponge rubber is actively working on various test methods that are in use and attempts will be made to develop standard procedures.

Soaps and Detergents

Concentrated work during the year by the members and officers of Committee D-12 on Soaps and Detergents resulted in considerable impetus to its standardization program. Eight new tentative standards were issued, four of these being specifications for white floating toilet soap, chip soap, powdered laundry soap and ordinary laundry bar soap. Two were methods, one covering particle size of soaps and other detergents and the other methods for determination of combined sodium and potassium oxides in soaps. Two chemical methods cover sulfonated (sulfated) oils and special detergents.

An article in the December BULLETIN, page 37, on the committee's latest meeting in November in New York City, lists many of the active projects, particularly those in which some proposed methods or tests are anticipated during 1939. The committee has approved drafts of specifications for trisodium phosphate and sodium metasilicate. Complete specification drafts for soap powders and built soaps may be completed in the near future. One group concerned with nomenclature and definitions has devoted considerable discussion to the subject of soap powder, and has proposed definitions (on which comments are invited) to clarify confusion with respect to this term. Other active projects involve dry cleaning detergents, metal cleaners, methods of measuring detergency and tests for soaps (rosin, carbon dioxide, Wijs iodine test, etc.).

Textile Materials

Interest and activity in the work of Committee D-13 on Textile Materials during the past year has increased at an even faster rate than in the last two or three years. The membership has been materially augmented through the activities of the new section on staple fiber and spun rayon yarns and the formation of a new subcommittee on glass fiber and its products. At its two meetings in 1938 (each extending over three days), several important technical papers were presented, with two symposiums respectively on "Finishing" and "Spun Rayon and Blended Fibers." Articles on these meetings have appeared in previous BULLETINS.

Seven new standards were issued during the year covering test methods for fastness of colored textile fabrics to light (D 506), spun rayon yarns and threads (D 507), yarns spun from wool mixed with fibers other than wool (D 508), fiber length of wool (D 519), and specifications for bleached wide cotton sheeting (D 503), single-ply bleached cotton broadcloth (D 504), and terry (turkish) toweling (D 505).

An important change has been made in the method for handling definitions and terms relating to textile materials. All definitions and terms not specifically used in the standards have been deleted from the tentative standard on definitions (D 123 – 38T) and compiled in a glossary which appears as an appendix to the 1938 compilation of "A.S.T.M. Standards on Textile Materials."

Revisions were made in several standards, the more important being those relating to pile floor covering (D 418), wool felt (D 461), testing woven textile materials (D 39), tire cord (D 179), woolen yarns (D 403), worsted yarns (D 404), cotton yarns and threads (D 180), cotton sewing threads (D 204), cotton goods for rubber and pyroxylin coating (D 334), and specifications for textile testing machines (D 76).

The committee has many important projects and studies in progress (some 40 of these were mentioned in the December BULLETIN in an article on the October meeting of D-13 in New York City). These relate to the following: rayon staple and fabrics; grease wool, wool felt, and fineness of wool tops; glass roving, twine and fabrics; household fabrics; water resistance, moth repellancy and accelerated aging of textiles; moisture regain and conditioning of textiles; specifications for testing machines; jute yarns; asbestos cloth; and definitions.

Naval Stores

New tentative methods of sampling and grading rosin (D 509) were issued through the work of Committee D-17 on Naval Stores. These make available in greater detail than given in the regulations of the Naval Stores Act the various methods of sampling rosins. The committee's work on softening point of higher melting rosins is being continued involving comparative tests of the tapered ring-and-ball and the shouldered ring-and-ball methods.

The increasing need of a rapid method for determining the crystallizing tendency of rosin is recognized and study of such methods is continuing. In one method the rosin is made into a concentrated solution using acetone as a solvent; in the other the material is held in a molten condition in an air or electric oven, the length of time which elapses before crystals formed being noted.

Plastics

During the second year of its existence, Committee D-20 on Plastics has been concentrating its efforts on the development of testing methods. Fortunately Committee D-9 has already done much work in this field, so that in some cases Committee D-20 need only use the findings of Committee D-9. In other cases, certain modifications will be recommended, in order that the methods adopted for testing plastic insulating materials may be expanded and made applicable to all kinds of plastics. Much of the work of Committee D-20, however, is being directed towards the development of testing methods for properties which find their major significance when evaluating plastics for other than insulating purposes.

The methods which are at present being actively studied include flexural strength, tensile strength, resistance to impact, resistance to abrasion, resistance to scratching, gradual distortion under load, plasticity, flammability, transparency to light, refractive index, surface irregularities, absorption of water, and resistance to chemicals.

A great deal of "round robin" testing has been done, and the findings have been discussed in detail by correspondence and at numerous meetings of the subcommittees and sections.

Water for Industrial Uses

The work which Committee D-19 on Water for Industrial Uses has had under way resulted in 1938 in the issuance of seven tentative methods of sampling and analysis. These methods cover sampling of plant or confined waters and determination of the following ions: calcium, magnesium, chloride, carbonate, bicarbonate, hydroxide, orthophosphate and sulfate; also total carbon dioxide and total orthophosphate.

The committee is interested in several projects, one involving the development of methods for the sampling of water and of steam. Published information has been accumulated and this is being studied. Preparation of additional methods including referee and field methods for determination of dissolved oxygen in water, and for iron, alumina, and manganese are under way; also studies for the improvement of the present field method for the determination of hardness in water.

Information has been developed on current practices in the use of the existing method for hardness testing by the use of soap and also on a titration method for the determination of hardness. The subcommittee concerned with classification whose scope involves the development of specifications for expressing analytical data and methods for interpreting the analysis of water is making excellent progress in one phase of its work, namely, the preparation of a tentative specification covering a statement of the water analysis report.

Methods of Testing

The work of Committee E-1 on Methods of Testing, involving so many diverse fields, has continued actively. Changes were developed in the method of bend testing for ductility of metals (E 16) and of particular importance was the completion of new tentative specifications for sieves for testing purposes, superseding immediately the standard specifications E 11 and E 17. Thus, the new specifications which are a revision and consolidation of the two standards provide a uniform standard covering wire cloth sieves and round-hole and square-hole screens or sieves. The section on impact testing sponsored the extensive symposium on this subject held at the annual meeting in Atlantic City.

Work on speed of testing under the committee's auspices is being carried out at the University of Illinois assisted by a grant from the A.S.T.M. Research Fund. The ultimate objective of this work is to develop a basis of methods of expressing speed of testing and tolerances for speed limitations.

There is considerable interest in the work of Technical Committee XII on Laboratory Glassware (formerly Committee D-15 on Thermometers). As problems on instrument requirements develop in other standing committees in the work of writing specifications, it is expected that this technical committee will more and more be called into consultation and asked for recommendations.

The first of three papers sponsored by Committee E-1 on testing of various types of glassware apparatus was given at the annual meeting and appears as an appendix to the 1938 report. This covers "Methods of Testing Thermometers," by E. F. Mueller and R. M. Wilhelm. Other papers on testing of hydrometers and calibrated glass are in course of preparation.

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